External evaluation of mobile phone technology-based nutrition and agriculture advisory services in Africa and South Asia

Mobile phones, nutrition, and agriculture in Ghana: Quantitative endline report

Lucy Billings, Daniel O. Gilligan, Melissa Hidrobo, Giordano Palloni, and Heleene Tambet (International Food Policy Research Institute)

15 October 2020

e-Pact is a consortium led by Oxford Policy Management and co-managed with Itad

Acknowledgements

The International Food Policy Research Institute (IFPRI) team would like to thank all individuals in Upper West and Central regions who agreed to take part in this research. We are particularly grateful to the Institute of Statistical, Social, and Economic Research (ISSER) team in Ghana, led by Simon Bawakyillenuo and Felix Asante, for leading the data collection effort. We would also like to extend our sincere gratitude to the Groupe Spéciale Mobile Association (GSMA), Esoko, Vodafone Ghana, and Global Alliance for Improved Nutrition (GAIN) teams for their ongoing cooperation and support for the evaluation.

We are also extremely grateful for the ongoing collaborative partnership with the Institute of Development Studies (IDS), which is overseeing the evaluation's qualitative component, led by Inka Barnett, as well as the Gamos team overseeing the business model component, led by Simon Batchelor. Both teams have provided invaluable feedback and support towards the quantitative design and tools as well as comments on drafts of this report. The team would also like to thank the Foreign, Commonwealth and Development Office (FCDO) and Oxford Policy Management (OPM) teams for their continued support and contributions on this project. We gratefully acknowledge funding for this research from FCDO and from the Dutch Government through SNV Netherlands Development Organisation and the Voice for Change Partnership Programme.

Disclaimer

This material has been funded by UK aid from the UK government and by SNV from the Dutch Government; however, the views expressed do not necessarily reflect the UK or Dutch governments' official policies.

This project is being led by the Institute of Development Studies (IDS) together with Gamos and the International Food Policy Research Institute (IFPRI) as part of the e-Pact consortium led by Oxford Policy Management (OPM) co-managed with Itad. The IDS project manager is Jessica Gordon [j.gordon@ids.ac.uk]. The report authors are Lucy Billings, Daniel Gilligan, Melissa Hidrobo, Giordano Palloni, and Heleene Tambet. For further information contact j.gordon@ids.ac.uk.

The contact point for the client is Luisa Odell [luisa.odell@fcdo.gov.uk]. The client reference number for the project is PO6420.

e-Pact
Level 3, Clarendon House
52 Cornmarket Street
Oxford OX1 3HJ
United Kingdom
Tel +44 (0) 1865 207300
Fax +44 (0) 1865 207301
Email admin@opml.co.uk
Website www.opml.co.uk

Data management

All intellectual property rights in any materials produced from the evaluation (including publication of research findings and any other reports and data) remain the property of IDS and associated subcontracted collaborators. IDS and all subcontracted partners undertaking data collection have specific arrangements in place for handling data generated from the project in accordance with the Data Protection Act (1998), which includes the processing and storage of any sensitive personal data and maintenance of privacy. FCDO has unlimited access to any material produced from the evaluation. In order to promote the use and uptake of the evaluation findings and in line with FCDO's Open and Enhanced Access Policy, the evaluation team is committed to ensuring all major report outputs and associated data generated from this project are made publicly available in an accessible format. Following approval of the report from FCDO, the endline report will be made available on IFPRI and IDS's websites. All datasets will also be made available within 12 months of final data collection on IFPRI's page at the Harvard Dataverse website: https://dataverse.harvard.edu/dataverse/IFPRI.

Executive summary

The mNutrition intervention in Ghana

mNutrition is a five-year global initiative supported by the UK Foreign, Commonwealth and Development Office (FCDO), managed by Groupe Spéciale Mobile Association (GSMA), and implemented by in-country mobile network operators (MNOs) and third-party providers, which aims to use mobile technology to improve the health and nutritional status of children and adults in low-income countries around the world. mNutrition is implemented through existing mAgri and mHealth Value Added Services (VAS) in 12 countries throughout sub-Saharan Africa and South Asia. The nutrition content aims to promote behaviour change around key farming practices and around dietary and child feeding practices that are likely to result in improved nutritional health within households.

The mNutrition service that is the focus of the evaluation in Ghana and this report is the Vodafone Farmers Club (VFC) service. The service is a 'bundled solution', offering both agricultural and nutrition information through mobile voice services, SMS services, and an expert call centre (provided by Esoko), as well as offering free to others with VFC SIM cards. The objective of Vodafone's service is to create and scale commercially sustainable mobile services that enable smallholder farmers to improve the nutritional status of their household and increase their productivity.

Evaluation design

The aim of the impact evaluation is to assess the impact, cost effectiveness, and commercial viability of two services within the broader portfolio of the GSMA mNutrition programme. The evaluation is being conducted by a consortium of researchers from Gamos, the Institute of Development Studies (IDS), and the International Food Policy Research Institute (IFPRI). The team draws on a number of methods and interlinked components to gather evidence about the impact of the VFC service in Ghana, including a qualitative component, a quantitative component, and a business model and cost effectiveness component. The evaluation is being conducted in two regions of Ghana: the Central region and the Upper West region.

This report focuses on the quantitative component, which employs a randomised encouragement design to determine the causal effect of the service on dietary diversity, agricultural income, and production. Households in study communities that were randomly assigned to the encouragement treatment arm were exposed to extra promotional activities to encourage an increase in take-up of the VFC service; households in communities that were randomly assigned to the comparison arm did not receive the extra promotional activities, but still had access to the nationally available VFC service. The additional marketing and promotion to encourage take-up and continued use was informed by the baseline qualitative study and included a combination of price discounts and door-to-door marketing throughout the evaluation period.

The evaluation design included several other components to provide evidence on factors affecting take-up and demand for the VFC service. In addition to the community-level randomisation, households in encouragement communities were randomly assigned to receive one of two scripts during the promotion campaign: (1) a script that focused on the agriculture-related value of the product (Vodafone's default script); or (2) a script that augmented the agriculture focus with additional information about the nutrition-related value of the product. Furthermore, in households with both an adult male and an adult female, the scripts and free subscription to the VFC service

were randomly read to and offered to either the adult male (primary male) or the adult female (primary female) from each household. Comparing outcomes from the two scripts informs whether emphasising the nutrition component of the service leads to higher willingness to pay (WTP) (which was addressed in the baseline report, (Billings *et al.*, 2018)). Comparing outcomes between male- and female-targeted households helps us understand how the gender of the person receiving the messages affects the household's utilisation of the information provided and final outcomes.

To assess the impacts of the VFC service on primary and secondary outcomes, we rely on the randomised encouragement design and estimate two distinct measures of impacts. The first are intent-to-treat (ITT) impacts that compare outcomes across households in communities that were randomly assigned to receive the door-to-door offer of the VFC service (i.e. the encouraged group) and households that were randomly assigned to not receive that offer (i.e. the comparison group). The ITT impact estimates measure the average impact of the VFC on households in communities randomly assigned to the encouragement campaign, regardless of whether the household signed up for VFC and continued to use it. The second impact measures are local average treatment effects (LATE). These, under additional assumptions, estimate the impact of receiving the mNutrition messages for households that were induced to register and use the VFC service by the random door-to-door offer ('compliers'). The LATE estimates represent the causal effect of exposure to VFC messaging on these compliers. However, the average causal effect that is estimated on compliers is not necessarily the average causal effect on the sample population. Consequently, in the following sections we estimate and discuss both parameters – ITT and LATE – in order to provide more complete conclusions about the causal effects of the VFC service.

The quantitative evaluation answers the following research questions:

1. How effective is the VFC service at increasing the knowledge and changing the behaviour of farmers?

2. What are the impacts of the VFC service on households' and women's dietary diversity, agricultural income, and production?

3. What is the demand for the VFC service and can framing about the agriculture or nutrition objectives of the service affect households' WTP for the service?

4. Does targeting women with the service have differential impacts on knowledge, behaviour, and final outcomes compared to targeting men?

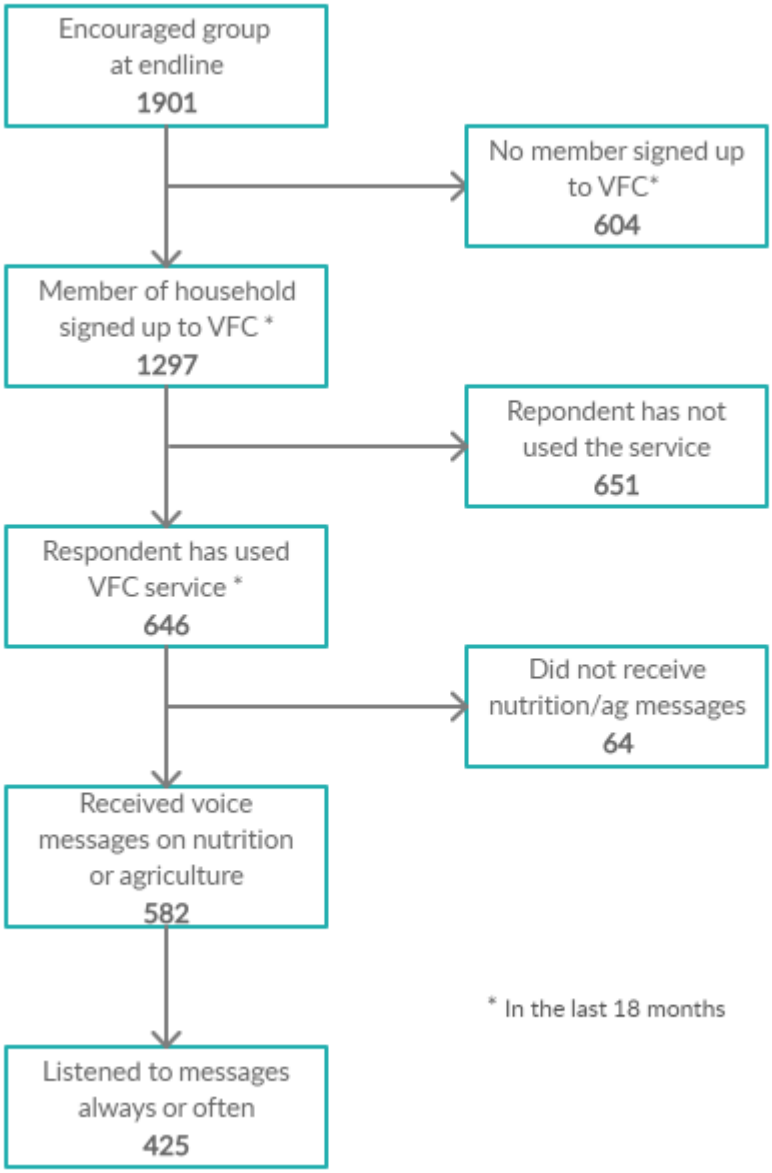
While the third research question was addressed in the baseline report, we address research questions 1, 2, and 4 in this report.

To measure the quantitative impacts of the programme on dietary diversity and agriculture production, baseline and endline surveys were conducted. The Institute of Statistical, Social, and Economic Research (ISSER) served as the in-country survey partner, leading the data collection in cooperation with the quantitative evaluation team from IFPRI. The baseline survey took place from March to May 2017 and collected information on 3,936 households across 207 enumeration areas (EAs) from the Upper West and Central regions. The endline survey took place from November 2018 to February 2019, and successfully re-surveyed 3,802 of the same households.

Exposure and experience with VFC service

Relative to the comparison group, **households in the encouragement group were 67 percentage points more likely to have registered for the VFC service** (68% compared to 1%) following the extensive door-to-door campaign to promote the service and facilitate sign-ups. While 68% of households in the encouraged group had a member signed up at some point in the previous 18 months, only 26.7% of households had someone still signed up approximately 18 months after initial registration – which indicates high drop-out rates over time. Moreover, among households that had been signed up, only 49.8% of respondents reported that they had used the service in the previous 18 months (Figure 1.1). This means that **only 34% of encouragement households had used the service in the previous 18 months (646 households of the 1,901 encouraged households).** The main reason for encouragement households not using the service is losing or not using the SIM, followed by not having access to a mobile phone – the latter reason being significantly larger in the Upper West region compared to the Central region and among primary females compared to primary males. Phone malfunction and bad network connectivity were other frequently reported reasons, though these figured to a lesser extent.

Figure 1.1: Interaction with VFC service within encouraged group



Source: Authors' own

Of the 646 households that had used the VFC service at least once in the previous 18 months, approximately 8–11% never received any weather, market price, or agriculture/nutrition information and 64% never called the call centre to speak with an agriculture expert. Among households that did receive the market price, weather, or agriculture/nutrition messages, approximately 45% did not always or often read the weather or market price information, and 27% did not always or often listen to the agriculture/nutrition voice messages. The reasons for not actively interacting with the platform vary by component, region, and gender. For weather and market price information, which were delivered via SMS in English, the main reasons for not reading all the messages included not being able to read or not knowing English. For agriculture and nutrition tips, which were delivered via voicemail in the local language, the main reasons included not having access to a phone, receiving too many messages, and weak service. For using the call centre to speak with an agriculture agent, the main reasons for not using the service included not knowing that it was available, followed by believing that there was a charge for the service. Households in the Upper

West region were more likely than those in the Central region, and women were more likely than men, to report not actively reading the weather and market price information because they could not read and not listening to the agriculture and nutrition voice messages because they did not have access to a mobile phone.

Although active participation among the encouraged households was low, respondents' perceptions of the service were quite favourable for several service components. The majority of respondents that had received the messages indicated that they found the content of the VFC service useful, that it had changed their behaviour, and that they trusted and felt confident in the information. Overall, the most useful and trusted component was the agriculture expert advice from the call centre (96% of households that used the service reported finding the information useful and 94% agreed that they trusted the service) (although note that this was the least used and known component), followed by the agriculture/nutrition tips (72% of households that received the information found it useful, and 81% agree they trusted the information). Respondents in the Central region were more likely to find the weather and agriculture/nutrition messages useful compared to respondents in the Upper West region. Overall quality ratings of the service were around seven out of 10. The highest quality ratings were given to agricultural and nutrition tips (7.1 out of 10 for males and 7.36 out of 10 for females). Ratings were higher in the Central region compared to the Upper West in every category and among females compared to males in seven of the eight categories, with the exception being 'ease of use'.

The impact of the VFC service on primary and secondary outcomes

Being offered the VFC service (ITT) or having used it at least once (LATE) has minimal impact on primary outcomes related to household and women's dietary diversity, agriculture production, or agricultural income. In most cases, ITT point estimates result in precisely estimated zeros. This is not surprising given the low take-up and limited usage of the service. Consistent with the null results on primary outcomes, **we find no evidence that access to the VFC service led to improvements in secondary outcomes related to nutrition, farming knowledge, or market access of the primary male or primary female, the exception being a significant increase of 0.32 Ghanian Cedis (GHC) in the highest price received for maize for the primary female.** The lack of overall impacts makes it impossible to conclude whether a better designed or better implemented programme with higher active usage rates would have led to positive impacts on the nutrition and livelihoods of farmers.

Although there are no impacts on average of being offered the VFC service, there are a few differences in impact across the gender of the person targeted, the region, and poverty level. First, **targeting the primary female makes her significantly more likely to consume dairy, but this is not true if the primary male is targeted.** These differences are significant, suggesting that, at least in the case of dairy consumption, targeting matters. However, **targeting the primary male leads to a significantly higher maize price received for the primary female**, and, although impacts across targeting the female or male are not significantly different, this suggests that market price information is being shared from male to female. Second, **impacts on household dietary diversity and market price received for maize are positive and significant in the Central region but not the Upper West region**, and differences across regions are significant. This is consistent with self-reported usage and perceptions of the VFC service, where households from the Central region reported reading or listening to the messages more often, found the messages more useful, and gave a higher quality score to the service compared to households in the Upper West region. Lastly, poverty matters for impacts on maize yields and market outcomes, but not diets or knowledge. In particular, **impacts on maize yields and market outcomes related to the**

price received for groundnut are larger the more likely you are to be below 150% of the national poverty line (NPL).

The impact of the VFC service on mobile phone use

Beyond the primary and secondary outcomes, we also use the encouragement design to identify the impact of the offer of the VFC service on the reported mobile phone use of the primary male and primary female. We find that **the VFC offer led to significant increases in the proportion of phone numbers that used Vodafone as the network provider (an increase of about 9.6 percentage points for the primary female and 11.4 for the primary male) and the likelihood that Vodafone was the main network provider (an increase of about 8.9 percentage points for the primary female and 9.4 for the primary male).**

The encouragement also led to significant increases in the likelihood that the primary female and primary male had ever used their phone to receive agriculture advice (a 5.4 percentage point increase for the primary female and a 15.9 percentage point increase for the primary male) or had ever received a text message with information on agriculture, weather, market prices, or nutrition (a 14.2 percentage point increase for the primary female and 38.4 for the primary male). This is consistent with the study design and intervention, which provided free Vodafone SIMs that sent agriculture and nutrition messages to encouraged households. The VFC service did not, however, increase usage in terms of using the main mobile phone to make or receive calls, make or receive text messages, or on the total amount spent on airtime, and it led to a significant decrease in the probability that the primary female or primary male used the main mobile phone to send mobile money, of approximately 2.1 and 3.7 percentage points, respectively.

Policy Implications

Although low cost and valued by users who engage with the service, mobile phone-based services are not a magic bullet. Practical challenges remain for mobile phone-based services to be an effective means of improving nutrition and agriculture outcomes. In contrast with more typical in-person methods of conducting behaviour change communication, whereby programme staff deliver content to beneficiaries by meeting with them directly, in order to work, mobile phone-based information interventions need to ensure that targeted mobile phone numbers have access to strong network services, are activated, profiled, frequently used, charged, and accessible, and also that the desired user has the time, ability, and desire to read or listen to the delivered content. The limited impacts of VFC can be explained by shortcomings in the available supportive infrastructure (such as weak network or not preferred network), the capacity of the intended VFC recipients (for example high illiteracy), and limitations in the implementation and design of VFC. The results and conclusions presented in this report are corroborated and triangulated with the other components of the evaluation (Barnett et al, 2020).

The lack of impacts makes it impossible to conclude whether a better designed and implemented service would have led to improvements in the nutrition and livelihoods of farmers. However, we have shown that a mobile phone intervention that is light touch and insufficiently engaging to promote regular use did not change agriculture and nutrition outcomes. While this result may be due in part to weaknesses in delivery, it is also consistent with the broader literature. Many evaluations of agriculture and nutrition interventions show that sustained programming with multiple delivery channels is often needed to change behaviour and see impact, particularly on nutrition. Thus, mobile phone-based interventions such as VFC are unlikely to be effective as a standalone channel for promoting behaviour change; they may perform best when integrated with

traditional media or in-person visits as part of a multi-level strategy. Mobile phone-based information could therefore be one part of a broad, many-pronged policy, and not the only component aiming to change nutrition behaviour and practices.

Key highlights

- While 68% of households in the encouraged group had a member signed up for VFC at some point in the previous 18 months, only 26.7% of households had someone still signed up approximately 18 months after initial registration, indicating high rates of dropout.
- Of households that had signed up for the VFC service, only about half report using the service in the previous 18 months.
- The main reason for not using the service is losing or not using the SIM, followed by not having access to a mobile phone, the latter reason being significantly larger in the Upper West region compared to the Central region and among primary females compared to primary males.
- Among respondents that received the market price, weather, or agriculture/nutrition messages, approximately 45% did not often read the weather or market price information and 27% did not often listen to the voice messages related to agriculture and nutrition information.
- The main reasons for not actively interacting with the weather and market price information, which was delivered via SMS in English, are not being able to read or not knowing English. For agriculture and nutrition tips, which were delivered via voicemail in the local language, the main reasons were weak service, receiving too many messages, and not having access to a phone. For using the helpline to speak to an agriculture agent, the main reasons for not using the service were not knowing that it was available, followed by not needing to use it and believing that there was a charge for the service.
- Although active participation among the encouraged households is low, respondents' perceptions of the service, for the subgroup of households that have used it, is quite favourable. The overall rating of the service is 7/10.
- On average, there are minimal impacts of being offered or using the VFC service on household or women's diet, agriculture production or income, and nutrition or farming knowledge.
- However, targeting the primary female makes her significantly more likely to consume dairy, but the same is not true if the primary male is targeted, and this difference is significant.
- Impacts on household dietary diversity and market prices received for maize are positive and significant in the Central region but not the Upper West region, and differences across regions are significant.
- Impacts on maize yields and market outcomes related to prices received for groundnut are significantly larger the poorer the household.
- Being offered the VFC service leads to a significant increase in the likelihood that the primary male or primary female has Vodafone as the main network provider, uses their mobile phone to receive agriculture messages, and has ever received text messages with information on agriculture, nutrition, weather, or prices. However, there are no impacts on reported mobile use in terms of using the main mobile phone to send or receive voice calls, send or receive text messages, or on the value of airtime minutes.

Table of contents

List of figures and tables

List of abbreviations

2SLS	Two-Stage Least Squares
ANCOVA	Analysis of Covariance
CAPI	Computer-Assisted Personal Interview
CLE	Community Listing Exercise
DFID	Department for International Development (UK)
EA	Enumeration Area
FCDO	UK Foreign, Commonwealth and Development Office
GAIN	Global Alliance for Improved Nutrition
GHS	Ghanaian Cedi
GLSS	Ghana Living Standard Survey
GSMA	Groupe Spéciale Mobile Association
HDDS	Household Dietary Diversity Score
ICT	Information and Communication Technology
IDS	Institute of Development Studies
IFPRI	International Food Policy Research Institute
HIS	Inverse Hyperbolic Sine
ISSER	Institute of Statistical, Social, and Economic Research
ITT	Intent-to-Treat
LATE	Local Average Treatment Effect
MDD-W	Minimum Dietary Diversity – Women
MNO	Mobile Network Operator
NPL	National Poverty Line
OLS	Ordinary Least Squares
OPM	Oxford Policy Management
PPI	Poverty Probability Index
SIM	Subscriber Identity Module
SMS	Short Message Service

VAS	Value Added Services
VFC	Vodafone Farmers Club
WTP	Willingness to Pay

1 Introduction

1.1 mNutrition

mNutrition is a global initiative supported by FCDO, organised by GSMA, and implemented by in-country MNOs and third-party providers that aims to use mobile technology to improve the health and nutritional status of children and adults in the developing world. A consortium of researchers from Gamos, IDS, and IFPRI have been contracted to conduct a rigorous mixed-methods evaluation to estimate the impact of two mNutrition services on children and adults and to assess how the context and the components of the mNutrition intervention shape its impact.

mNutrition is being implemented through existing mAgri and mHealth services in 12 countries throughout sub-Saharan Africa and South Asia. The nutrition content aims to increase knowledge and promote behaviour change around key farming decisions and practices, and around maternal and other household practices that are likely to result in improved nutritional health within a household. The mNutrition initiative aims to lead to the following changes in outcomes: (i) increased adoption of new nutrition-sensitive agriculture practices, improved agricultural productivity, and greater use of post-harvest technologies; (ii) improvements in nutrition practices around women during pregnancy, infant and young child feeding, and micronutrient supplementation of children at risk; and (iii) increased demand for nutrition and agriculture extension services.

The evaluation is expected to measure the impact, cost effectiveness, and commercial viability of mNutrition, using a mixed-methods design. The evaluations are being conducted on two services: Ghana mAgri (the focus of this report) and Tanzania mHealth. In order to satisfy the objectives of the Terms of Reference, the evaluation is composed of the following components:

- A **quantitative impact evaluation**, employing a randomised encouragement design to determine the causal effect of the service on dietary diversity, agricultural income, and production. A baseline survey was carried out before the start of the encouragement activities, and an endline survey 18 months later.
- A **qualitative impact evaluation**, which consists of three qualitative data collection rounds (i.e. an initial exploratory qualitative study, in-depth case studies at midline, and rapid explanatory qualitative work after the quantitative endline survey data collection) and aims to provide understanding of the context, underlying mechanisms of change, and the implementation process of mNutrition.
- A **business model and cost effectiveness evaluation** employing stakeholder interviews, commercial and end-user data, document analysis, and evidence from the quantitative and qualitative evaluations to generate a business model framework and estimate the wider imputed benefits from the VAS for the range of stakeholders involved.

The mixed-methods evaluation design addresses the following research questions specified in the Terms of Reference (see Annex A):

1. What are the impacts and cost effectiveness of mobile phone-based nutrition and agriculture services on nutrition, health, and livelihood outcomes, especially among women, children, and the extreme poor?
2. How effective are mobile phone-based services in reaching, increasing the knowledge, and changing the behaviour of the specific target groups?

3. Has the process of adapting globally agreed messages to local contexts led to content that is relevant to the needs of children, women, and poor farmers in their specific context?
4. What factors make mobile phone-based services effective in promoting and achieving behaviour change (if observed), leading to improved nutrition and livelihood outcomes?
5. How commercially viable are the different business models being employed at country level?
6. What lessons can be learned about best practices in the design and implementation of mobile phone-based nutrition services to ensure (a) behaviour change and (b) continued private-sector engagement in different countries?

Individual technical reports have been written for each component – quantitative, qualitative, and business model and cost effectiveness, each addressing different parts of the Terms of Reference. There have been no major divergences in the research questions specified in the TOR, although some additional questions were added to the quantitative component (see section 1.3).A mixed-methods report combines the findings of the three components of the evaluation in order to build a deeper understanding of, and gather lessons learned about, best practices in the design and implementation of mobile phone-based information services to ensure (a) behaviour change and (b) continued private sector engagement in different countries (Barrett et al 2020).

The primary target user of the evaluation results is FCDO, along with other key stakeholders including GSMA and its national members (including Vodafone and other local MNOs implementing VFC services), national governments (in particular, the ministries of health and agriculture), international agencies and donors, as well as community-level health and agriculture extension workers. Consultations and workshops with stakeholders occurred throughout the evaluation with in-country visits at the start of the evaluation to discuss and finalize the design of the evaluation and then to present baseline findings. The findings of this report were presented and discussed with key stakeholders during an interactive webinar in April 2020. The reports from the evaluation, which have been reviewed and commented on by stakeholders, will be publicly available on IFPRI and IDS's websites, and will continue to be disseminated widely through webinars, international conferences, journal publications and blog posts.

1.2 Objectives of mNutrition within mAgri

mNutrition within the mAgri programme aims to improve nutrition by promoting behaviour change around key farming decisions and practices – increasing the productivity, crop quality, and income of smallholder farmers. The potential of a nutrition-sensitive agriculture mobile platform to improve nutrition is large, but as yet, relatively untested.[1] The objective of mAgri is thus to create and scale commercially sustainable mobile services that enable smallholder farmers to improve their livelihood and nutritional outcomes (see Annex C for GSMA's Theory of Change for the mAgri programme).

In Ghana, mNutrition is being implemented as part of the Vodafone mAgri VAS, a mobile extension service called VFC. The service is a bundled solution offering agricultural and nutrition information via voice and SMS services in addition to free calls to other VFC members (details on the service are provided in Section 2).

[1] For a detailed landscape analysis of the context for implementing mNutrition and mAgriculture programmes, see Barnett *et al*. (2016).

1.3 Research questions of the quantitative component

To determine whether the VFC service in Ghana is meeting its stated objective of improving the livelihoods and nutritional outcomes of smallholder farmers, the quantitative impact evaluation employed a randomised encouragement design to estimate the causal effect of the VFC. The quantitative evaluation answers the following two primary research questions:

1. How effective is the VFC service at increasing the knowledge and changing the behaviour of farmers (intermediary or secondary outcomes)?
2. What are the impacts of the VFC service on households' and women's dietary diversity, agricultural income, and production (final or primary outcomes)?

These two research questions provide evidence to inform the first two overall evaluation questions listed in the Terms of Reference. The primary outcomes include those related to diets and productivity, which are part of the Theory of Change to improved nutrition. In addition to the two primary research questions, the impact evaluation addresses two additional questions, which aim to build knowledge around appropriate service targeting and to inform business models for future programmes:

3. What is the demand for the VFC service and can framing about the agriculture or nutrition objectives of the service affect households' WTP for the service?
4. Does targeting women have differential impacts on knowledge, behaviour, and final outcomes compared to targeting men with the service?

Research question 3, which was addressed in the baseline report, provides additional information to inform evaluation question 2, about the effectiveness of the service, and evaluation question 5, about the business model and commercial viability of VFC. Research question 4 contributes evidence to evaluation question 1, on the impacts of the service, and also to evaluation question 4, on what factors contribute to the impact of the service.

1.4 Objectives of the quantitative endline report

The purpose of this endline report is to introduce the context for this evaluation, describe the VFC service in Ghana, discuss the evaluation design and sample, present users' experience with the service, and provide estimates of programme impact from the endline data. The endline report is organised as follows. Section 2 describes the VFC service evaluated in this study and Section 3 covers the evaluation design. Section 4 provides detail on the endline data collection and Section 5 presents users' experience with the service. Sections 6, 7, and 8 present impact estimates of the VFC service. Section 6 presents ITT estimates of being randomly offered the VFC service, while Section 7 presents LATE estimates of being exposed to the service for households that registered for the service as a result of the randomised encouragement. Section 8 presents the heterogeneous impacts of being offered the VFC service across the gender of the person targeted to receive the VFC service, region, and wealth. The final section concludes with a summary of the endline findings and the challenges and limitations of the study.

2 The mNutrition intervention in Ghana

2.1 Context

Nutrition: Ghana has achieved substantial progress in reducing malnutrition and is on course to achieve most of the World Health Assembly Global Nutrition Targets set for 2025 (Development Initiatives, 2018). Improvements have been seen in the reduction of stunting among children under five years of age, which fell from 28.1% in 2008 to 18.8% in 2014 (Ghana Statistical Service *et al*., 2015). However, geographic disparities in nutritional status persist, with stunting prevalence at 22.2% in the Upper West region and 22% in the Central region, well above the national average and more than twice the rate in the Greater Accra region (Ghana Statistical Service *et al*., 2015). Micronutrient deficiency is also a persistent challenge, with more than 35% of children under five years suffering from anaemia and more than 20% suffering from vitamin A deficiency (University of Ghana *et al*., 2017).

Literacy in Ghana: Adult literacy rates in rural Ghana are quite low, with only 41.7% of adults able to read or write in English or any Ghanaian language (Ghana Living Standard Survey (GLSS) 6). Among rural women, rates are even lower (31.4%).

Mobile penetration: Use of mobile phones has increased dramatically in the last decade, from 19% of households owning a mobile phone in 2005/06 to 94% in 2016/17 (GLSS 7). While there is still some variation in mobile phone ownership by geographic location and poverty status, these gaps are narrowing quickly; 86.4% of households in the lowest wealth quintile now own a mobile phone (GLSS 7). The market for mobile services in Ghana is dominated by three MNOs. MTN is the largest, with 49.08% of market share for voice subscriptions and 59.74% of market share for mobile data subscriptions. Airtel/Tigo holds 25.14% and 23.21% of market share for voice and data subscriptions, respectively, while Vodafone holds 23.97% and 16.09%, respectively. Glo, a fourth MNO, covers less than 2% of the market share (Ghana National Communications Authority, 2018).

Agriculture in Ghana: Agriculture accounts for 22.2% of national gross domestic product (GLSS 7). A little over half (51.5%) of households in Ghana own or operate a farm. Farming is predominantly a rural activity, with 82.5% of rural households involved in agriculture, compared to only 26.6% of urban households. The proportion of females involved in agriculture is 41.2%, and there is virtually no difference in the gender balance between urban and rural areas (GLSS 6).

Agriculture extension services are decentralised, but provision remains poor due to low capacity and limited funds (World Bank, 2017). In 2014, there were approximately 3,500 agriculture agents under the Ministry of Food and Agriculture (Dia *et al*., 2017). Nutrition has not been a central outcome of traditional agricultural extension in Ghana, which also has limited capacity for reaching remote areas and female farmers. According to the Ghana Socioeconomic Panel Survey baseline report (2011), 51.7% of all households surveyed received agricultural advice from other households, and the proportion of households receiving agriculture extension advice through radio varied from 13.79% in the Northern region to 0.26% in the Greater Accra region.

mAgri services: The widespread penetration of mobile phone use in Ghana has come with a proliferation of tech start-ups, several with an explicit agricultural focus (for example, Anitrack, Complete Farmer, Ghalani, Qualitrace, and TroTro Tractor).[2] The VFC, which was introduced in 2015, is one such mAgri service, described in greater detail in Section 2.2. Farmerline is a social enterprise company that develops information and communication

[2] Many services started after 2014, when this project was conceptualised.

technology (ICT) for rural famers. In 2013, Farmerline launched the 399 service in partnership with MTN, which connects farmers to financial services, information, and agricultural inputs. Agrocenta facilitates smallholder farmer trade via AgroTrade (a platform for farmer registrations, inventory management, logistics, and tracking) and provides financial services via AgroPay (a platform for digital payments, micro-lending, and crop insurance). Mobile services for livestock farmers include Cowtribe, which enables subscribers to schedule and receive veterinary treatment for livestock and track the health statistics of each animal, and Agro Innova, providing software for poultry farmers, including AkokoTakra for production management and AkokoMarket for connecting farmers to markets. A few services aim to support logistics, including Ghalani, a platform for farmers to organise group deliveries, and TruckR, which allows farmers to book a truck on a mobile app to take products to market. Viamo, a global social enterprise with origins in Ghana, developed the 3-2-1 service, a mass communication tool used for the delivery of information-based services (including mHealth services) in a number of developing countries. In Ghana, 3-2-1 was launched in April 2016 and delivers a range of service on the Vodafone network.

More recently, large MNO companies are starting to roll out business-to-person services, where agribusinesses pay farmers via mobile money for the product or services rendered (Loukos and Javed, 2018). There is also a growing interest in apps that enable the urban population to invest in agriculture, either through the provision of finance and information services to farmers or by coordinating labour for urban landowners.

2.2 The VFC service

VFC is a mobile extension service delivering agricultural and nutrition information to farmers via recorded voice and SMS messaging and providing access to a call centre (or helpline) for agricultural advice. Smallholder farmers with access to mobile telecommunications are the primary target for VFC enrolment. The service includes access to a call centre for expert advice without airtime charges, free calls and SMS messaging to other VFC subscribers, and discounted calls and SMS messages to non-VFC subscribers, in addition to information-based services. The information-based services include weather information, market price information, agriculture tips, and nutrition tips (Table 2.1). While the weather and market price information are sent via SMS in English, the agriculture and nutrition tips are sent via voice messages in the local language, given the low rates of literacy in Ghana.

Table 2.1: VFC information-based services

	Delivery mode	Frequency	Language
Local weather information	SMS	Three messages per week	English
Local market price information	SMS	One message per week	English
Agricultural tips for selected crop	Recorded voice message	Three per month	Local language
Nutrition tips (for selected crop and general)	Recorded voice message	Three per month[3]	Local language

Source: Authors' own

[3] Initially, the VFC service sent one nutrition message per month, but this was increased to three nutrition messages per month in July 2017.

Esoko Ghana, a mobile phone-based rural information service, curated the message content and operated the platform to send tailored SMS and recorded voice messages to member farmers, and also operated the call centre. Esoko developed the content for the crop-specific agricultural tips for 24 widely cultivated crops in Ghana. These tips covered recommended planting times and information on best practices for cultivation and harvest. Messages were sent according to planting cycles for specific crops and agro-climactic zones based on farmer profile information. Nutrition message content was developed by GAIN in 2015. GAIN created 312 crop-specific messages (13 messages per crop for the 24 Esoko-supported crops) with nutrition information on topics including food preparation, food hygiene, safety and storage, and processing. In 2017, the Grameen Foundation developed 26 additional nutrition messages focused on animal-sourced foods, including eggs, dairy, fish, and meat. VFC subscribers received both general nutrition tips and crop-specific nutrition tips, according to their profiled crop.

Vodafone invested in the VFC service with the aim of increasing penetration in rural Ghana through new subscriber acquisitions. The VFC service was launched in June 2015 and promoted by Vodafone agents with a dedicated VFC SIM card. The monthly subscription fee for VFC was initially GHS 2 (US$ 0.45). However, the agent-led model resulted in slow acquisitions and difficulty retaining active usership of the service. By November 2016 there were approximately 130,000 registered members, but fewer than 20% were active (GSMA, 2017). In December 2016, Vodafone added existing rural Vodafone customers to the service, thus increasing the VFC subscription rate to over 200,000. In addition, Vodafone made a strong push to increase acquisitions by temporarily dropping the monthly subscription fee between October 2016 and June 2017. In June 2017, the monthly service fee was reinstated at GHS 0.5. Monthly fees are automatically deducted from the subscriber's airtime balance when the balance is at least GHS 0.5.

The VFC service is designed to offer customised information to farmers based on their selected preferences. Initially, each new member was profiled by a Vodafone agent at the time of registration, indicating their preference of location for weather and market price information, their preferred language for receiving recorded voice messages, and their preferred crop choice for agricultural tips and price information. It became apparent, however, that much of the profiling data was not being collected by agents at the time of SIM registration. As a result, Esoko and Vodafone modified their strategy so that all profiling would be done through a follow-up call to new members by the VFC call centre after the SIM registration process had been completed. However, when Vodafone suspended the monthly service fee and initiated a large push to increase the member base in late 2016, it was no longer feasible for Esoko to follow up with each new VFC member individually. Instead, new members were given default profile options based on their district of residence, receiving agri and nutrition tips on the crop most widely grown in that district and in the language most widely spoken. Farmers were able to request modifications to the profile options through the call centre, but this was not widely publicised. As a result, new members were less likely to have customised options and may have received agricultural and nutrition tips for crops they did not cultivate.

Due to the challenges in building and maintaining a wide subscription base for VFC, Vodafone designed a new service to better meet the needs of rural famers called the *Connected Farmer*, which includes financial services delivered through the Vodafone Cash platform such as a savings package, a crop insurance offer, and a platform for connecting farmers to agri-business services, in addition to market information services available through VFC. This new offer was designed based on findings from market research conducted in 2018 that indicated that farmers are most interested in services with immediate financial benefits (e.g. access to finance) and far less interested in information-based services, even if the information is also intended to ultimately boost production and income. However, Vodafone planned to continue offering the VFC services to *Connected Farmer* members with the aim of building greater demand for such information over time. The

Connected Farmer was supposed to be rolled out in August 2018 and Vodafone planned to migrate existing VFC members to the new *Connected Farmer* service when it was launched, although study farmers would continue receiving the basic VFC service to maintain consistency in the mNutrition evaluation intervention. However, the launch was delayed and the *Connected Farmer* had not yet been initiated at the time this report was written.

In January 2019, Vodafone discontinued its contract with Esoko to deliver recorded voice content for VFC, although it continued to operate the VFC helpline. IFPRI contracted Esoko directly to continue sending the content to study farmers from January through March 2019. There was a small interruption in the voice message service before Esoko resumed sending content to study farmers in the third week of January under the IFPRI contract.

3 Evaluation design

3.1 Study design

This section draws heavily on Sections 3.1 and 3.2 of the baseline report, which provides detailed information about each step in the design of the quantitative evaluation (Billings *et al.,* 2018).

To estimate the causal impact of the VFC product, we implemented a randomised encouragement design. The encouragement design does not restrict access to the VFC service (as with a control group in a randomised control trial), but instead works by randomly assigning some communities or households to receive additional marketing and promotion of the service. Because the encouragement is randomly assigned, we use the systematic variation in take-up of the service created by the encouragement to measure the causal impact of the service as the difference in outcomes between encouraged and comparison communities at endline. As we showed in the baseline report (Billings *et al.*, 2018), random assignment ensures that baseline characteristics of children, households, and communities are similar, on average, across encouraged and comparison communities, minimising bias in impact estimates due to unobserved heterogeneity or selection. Similarly, the presence of other agriculture and nutrition interventions as well as access to public services was balanced across the encouraged and comparison communities as a result of randomisation, which limits the effect of confounding variables on the impact estimates. As a result, average differences in outcomes across the groups after the intervention can be interpreted as being truly caused by, rather than simply correlated with, the interventions.

The additional marketing and promotion to encourage take-up and continued use was informed by the qualitative study and includes a combination of price discounts, where the service was offered for free, and door-to-door marketing to households in selected communities throughout the evaluation period. During the door-to-door marketing, the service was promoted using a short advertisement script. Households in communities randomly assigned to receive the encouragement were further randomly assigned to receive one of two scripts: (1) a script that focused on the agriculture-related value of the service (Vodafone's current script); or (2) a script that augmented the agriculture focus with additional information about the nutrition-related value of the service. Comparing the outcomes from the two scripts helps to establish whether emphasising the nutrition component of the service leads to higher WTP and take-up of the programme. Last, we randomly targeted either an adult male or female from each household by reading the script to the targeted individual and offering the free subscription to the VFC service to the target individual.[4] Comparing outcomes between male- and female-targeted households helps us understand whether the gender of the person receiving the messages affects the household's utilisation of the information provided and the final outcomes.

Thus, the encouragement design is composed of the following five groups:

1. **Comparison group (Group 1):** EAs that are not receiving the extra marketing or promotion.
2. Encouraged group: EAs that receive the extra marketing and promotion in the form of door-to-door marketing and price discounts:
    - **Encouraged male, agri group (Group 2a):** Households that receive marketing scripts that focus on the agriculture-related value of the service and that target a male household member;

[4] In practice, this meant that the VFC SIM would be under the targeted individual's name.

- **Encouraged male agri+nutrition (Group 2b):** Households that receive marketing scripts that focus on the agriculture- and nutrition-related value of the service and that target a male household member;
- **Encouraged female, agri group (Group 2c):** Households that receive marketing scripts that focus on the agriculture-related value of the service and that target a female household member; and
- **Encouraged female, agri+nutrition group (Group 2d):** Households that receive marketing scripts that focus on the agriculture- and nutrition-related value of the service and that target a female household member.

Random assignment to the different intervention groups occurred in two stages. The first stage stratified EAs by region and then randomly assigned EAs to either the comparison group (Group 1) or the encouraged group (Group 2a, Group 2b, Group 2c, Group 2d). Stratification ensures even coverage of the intervention arms across regions, which facilitates subgroup analysis and improves the precision of estimates (Duflo *et al.,* 2007). We chose to randomise at the EA level as opposed to the household level because it is likely that individuals will discuss what they learn from the VFC with other community members; thus, even individuals who do not directly use the service may be exposed to the information through fellow community members, and they cannot be considered 'untreated'. Urban areas that make up more than one EA were clustered together for the randomisation to minimise the potential of spillovers.

The second stage of randomisation, assigning households to either Group 2a, 2b, 2c, or 2d, occurred at the household level for households in the encouraged EAs. Within each region, households were stratified by two-person (an adult male and an adult female present in the household) and adult female-only households. Households with two adults were randomly assigned to either the default agriculture marketing script or the agriculture+nutrition marketing script, and either the primary male or primary female (usually household head or spouse) was randomly selected to receive the marketing script.[5] Households with only a primary female were randomly assigned to the agriculture script or the agriculture+nutrition script. Randomised assignment of the topic in the marketing scripts and the gender of the targeted household member was done at the household level rather than at the EA level in order to increase the statistical ability to identify the effects of these treatments. Spillovers of information between households would reduce the estimated impacts of these information treatments, but we did not expect such spillovers to be large.

The proposed design allows us to answer our specific research questions by making the following comparisons:

- Comparison of the **combined encouraged group** (Groups 2a, 2b, 2c, and 2d) with the **comparison group** (Group 1): What is the absolute impact of the VFC offer on primary and secondary outcomes and behaviour relative to the comparison group (research questions 1 and 2 in Section 1.3)?
- Comparison of the **encouraged male group** (Groups 2a and 2b) with the **encouraged female group** (Groups 2c and 2d): What is the relative impact of targeting women on primary and secondary outcomes and behaviour (research question 4 in Section 1.3)?
- Comparison of the **encouraged agri group** (Groups 2a and 2c) with the **encouraged agri+nutrition group** (Groups 2b and 2d): Does framing the VFC as an agriculture and nutrition programme lead to differences in a household's WTP compared to framing as just an agriculture programme (research question 3 in Section 1.3)?

[5] See section 4.1 for more detail on how the primary male and female were selected.

As mentioned in Section 1, the first two comparisons related to research questions 1, 2, and 4 are addressed in this endline report. The third comparison related to research question 3 was addressed in the baseline report (Billings *et al.,* 2018) and its companion paper (Aker *et al.,* 2019).

3.2 Estimation strategy

The estimation methodology compares differences in outcomes of interest across the encouraged and comparison groups using data collected in the baseline and endline surveys. Detailed information was collected at baseline and endline on: (1) final (or primary) outcomes on which we expect to see impacts; (2) intermediate (or secondary) outcomes that may explain pathways of impact, such as changes in behaviour, knowledge, and practices; and (3) outputs such as take-up rates and factors that may affect take-up rates and use of the VFC service. The baseline survey was conducted between March and May 2017 and the endline survey between November 2018 and March 2019 on the same households and individuals. Although the endline survey took place in a different season to the baseline survey, the timing was right after the harvest season, which ensures optimal recall of agriculture production (a primary outcome of interest). Moreover, given the randomised study design, we still have comparable encouraged and comparison groups to estimate causal impacts. The quantitative data collection and analysis strategy, as well as the interpretation of the analysis findings, was informed by findings from the two qualitative data collection rounds.

3.2.1 ITT estimation

To evaluate the impact of the VFC service, we use the baseline and endline data and conduct an analysis of covariance (ANCOVA) estimation. ANCOVA specifications are more flexible than typical difference-in-difference models, allowing us to estimate rather than impose the autocorrelation in each outcome (McKenzie, 2012) and creating a better data fit. Moreover, there are substantial power gains in using ANCOVA models over difference-in-difference when autocorrelation is low, which is the case with many of our outcome variables.[6,7]

Using the ANCOVA model, we estimate the ITT effect as the difference in average outcomes between the comparison group and those that were assigned to the randomised encouragement group regardless of whether they participated in the VFC. The ITT is a clean experimental estimator that allows for imperfect compliance with the treatment assignment, as is typical in an encouragement design.

For comparison of the **combined encouraged group** (Groups 2a, 2b, 2c, and 2d) with the **comparison group** (Group 1), the exact empirical specification on the ANCOVA parametrisation in its simplest form is the following:

$$Y_{1hvr} = \beta_0 + \beta_1 Encouraged_{vr} + \beta_2 Y_{0hvr} + \gamma_r + \varepsilon_{hvr}$$

where Y_{1hvr} is the outcome of interest at endline for household *h* from EA *v* in region *r*, and Y_{0hvr} is the outcome of interest at baseline. $Encouraged_{vr}$ is an indicator for whether EA *v* was randomly assigned to receive the extra encouragement, and γ_r is the stratification indicator for region. β_1

[6] The ratio of the difference-in-differences variance to the ANCOVA variance is 2/(1+ρ), where ρ is the intracluster correlation coefficient, or the share of the total variance that is due to between-cluster, rather than within-cluster, variance. So when ρ=.25, with a single baseline and follow-up, the sample size needed is 60% higher with difference-in-differences than with ANCOVA to get the same power.

[7] For the primary outcomes under study, the autocorrelations between baseline and endline values are as follows: 0.22 for yield of maize, 0.24 for yield of cocoa, 0.21 for yield of groundnut, 0.12 for total profits, 0.20 for HDDS, and 0.10 for Women's Dietary Diversity Score.

measures the differences in outcomes of the encouraged versus comparison households, and thus the impact of being offered for free the VFC service through the door-to-door marketing. In some models, we also add extended controls. Extended controls increase the precision of the estimates and check for the robustness of the model above by adding additional demographic covariates, which were collected at baseline.

For comparison of the **encouraged female group** (Groups 2c and 2d) with the **encouraged male group** (Groups 2a and 2b), the exact empirical specification on the ANCOVA parametrisation is the following:

$$Y_{1hvr} = \beta_0 + \beta_1 Male_{hvr} + \beta_2 Female_{hvr} + \beta_4 Y_{0hvr} + \gamma_r + \varepsilon_{hvr,}$$

where $Male_{hvr}$ is an indicator for whether the VFC service was randomly targeted to a male in dual-headed households, $Female_{hvr}$ is an indicator for whether the VFC service was randomly targeted to a female in a dual-headed household, β_1 measures the impact of being offered the VFC service when it is targeted to males, and β_2 measures the impact when it is targeted to females. To test whether the ITT estimators are statistically different across male- and female-targeted households, we conduct Wald tests of equality of the two estimates.

3.2.2 LATE estimation

The specifications described above enable us to estimate ITT treatment effects; that is, the point estimates capture the impact of the random offer of access to the VFC service on primary and secondary outcomes. However, in our setting many households in the encouraged group who are offered the service may not actually take up the offer, even if it is free. Conversely, some households in the comparison group may also take up the service.

Under two assumptions,[8] we can estimate the LATE of registering for and using the VFC service for compliers, i.e. households that were induced to register and use the service by the randomly assigned door-to-door offer. The first assumption is that the randomly assigned door-to-door offer of the VFC service does not directly affect outcomes of interest, but instead indirectly affects them by increasing the likelihood that households received the VFC content on a mobile phone. Given that the door-to-door offers of the service were brief, occurred only twice, and did not disclose any nutrition or farming information, we believe that this assumption will hold. The second assumption is that the randomly assigned offer of the VFC service makes every person in the encouraged group more likely to register and use the service. This assumption would be violated if, for example, the script that offered the VFC service were so ineffective that it convinced households that otherwise would have discovered and registered for the service not to register. We do not believe this to be the case.

To measure the impact of the VFC service on compliers we estimate a LATE model using Two-Stage Least Squares (2SLS), where the randomised offer creates an instrument for registering for and using the VFC service. Specifically, we estimate the following models:

$$TT_{hvr} = \gamma_0 + \gamma_1 Encouraged_{vr} + \gamma_2 Y_{0hvr} + \gamma_r + u_{hvr}$$

$$Y_{1hvr} = \beta_0 + \beta_{1,2SLS}\widehat{TT_{hvr}} + \beta_2 Y_{0hvr} + \gamma_r + \varepsilon_{ihv}$$

where $Encouraged_{vr}$ is the indicator for whether the household resides in an EA v that was randomly assigned to receive the VFC offer, TT_{hvr} is an indicator for whether household h in EA v

[8] See Imbens and Rubin (2015) or Duflo *et al.* (2007) for a complete discussion.

actually registered and used the VFC service in the previous 18 months,[9] and $\widehat{TT_{hvr}}$ is the predicted value for registering for and using the service of household h in EA v from the first equation listed above. In this context, $\beta_{1,2SLS}$ represents the estimated effect of registering for and using the service for the subsample of households that are induced to participate in the service by the randomly assigned offer.

The LATE estimates for compliers provide a different but still policy-relevant parameter; they represent the causal effect of exposure to the VFC messaging. However, the average causal effect that is estimated on compliers is not necessarily the average causal effect of the sample population. Consequently, in the following sections we estimate and discuss both parameters – ITT and LATE – in order to provide more complete conclusions about the causal effects of the VFC service on the sample population and on compliers.

3.3 Sample design

3.3.1 Overview

The study takes place in two regions of Ghana – the Upper West and the Central region – which allows for a comparison of impacts across regions with different nutritional status and patterns of agriculture production. Within each region, five districts were selected based on the availability of Esoko market price information for crops and low VFC subscription rates. From each selected district, we randomly selected 20–21 EAs from a list of EAs within a 10-mile radius of a Vodafone cell phone tower.[10,11] The study comprised a total of 207 EAs (104 in the encouragement arm and 103 in the comparison arm). Figure 3.1 shows the distribution of EAs across the 10 study districts.

In each EA, we randomly sampled 19 farmer households to be included in the study and the baseline sample, for a total planned sample of 3,933 households. The criteria for inclusion in the sample are that households must: (1) be a farming household; (2) own a mobile phone; (3) not be a current member of VFC; and (4) have at least one female member aged 15–60 years old. The last criterion ensures that we can measure woman's dietary diversity (a primary outcome) in all our sample households. In order to establish which households meet our sampling criteria, a Community Listing Exercise (CLE) that collected information on all households in the selected EAs was conducted before the baseline survey.

With a fixed number of households sampled in each EA, the household sampling probabilities vary with EA size. It is possible to generate sample weights to use in the analysis to generate means and other sample statistics that are representative of the underlying population in the sampled regions and districts. However, the main focus of the evaluation is to generate unbiased estimates of impact in the households that are in the study. Random assignment of EAs to the encouraged or comparison group assures that treatment assignment is uncorrelated with these sample weights, so estimated impacts should not be affected by weights. As study locations are not statistically representative of the two regions, there is little motivation to include sampling weights to recover impact estimates that would be representative of the underlying population in the study areas.

[9] Use is an indicator that equals 1 if the household responds yes to the following question: 'Have you, (name of individual in N1_ID), used the VFC service in the previous 18 months (to either make or receive calls, send or receive SMS, receive agriculture or nutrition information, receive weather or market price information, or call the helpline)?'
[10] Urban areas that are made up of more than one EA were clustered together for randomisation.
[11] A 10km radius was suggested by Vodafone as a guide and used to create a list of eligible EAs, but we also used signal strength in the EA centre as a screening test for EA inclusion in the sample at the time of the census. EAs with weak Vodafone signal were dropped from the sample list and replaced by another EA (see Billings *et al*. (2018) for details).

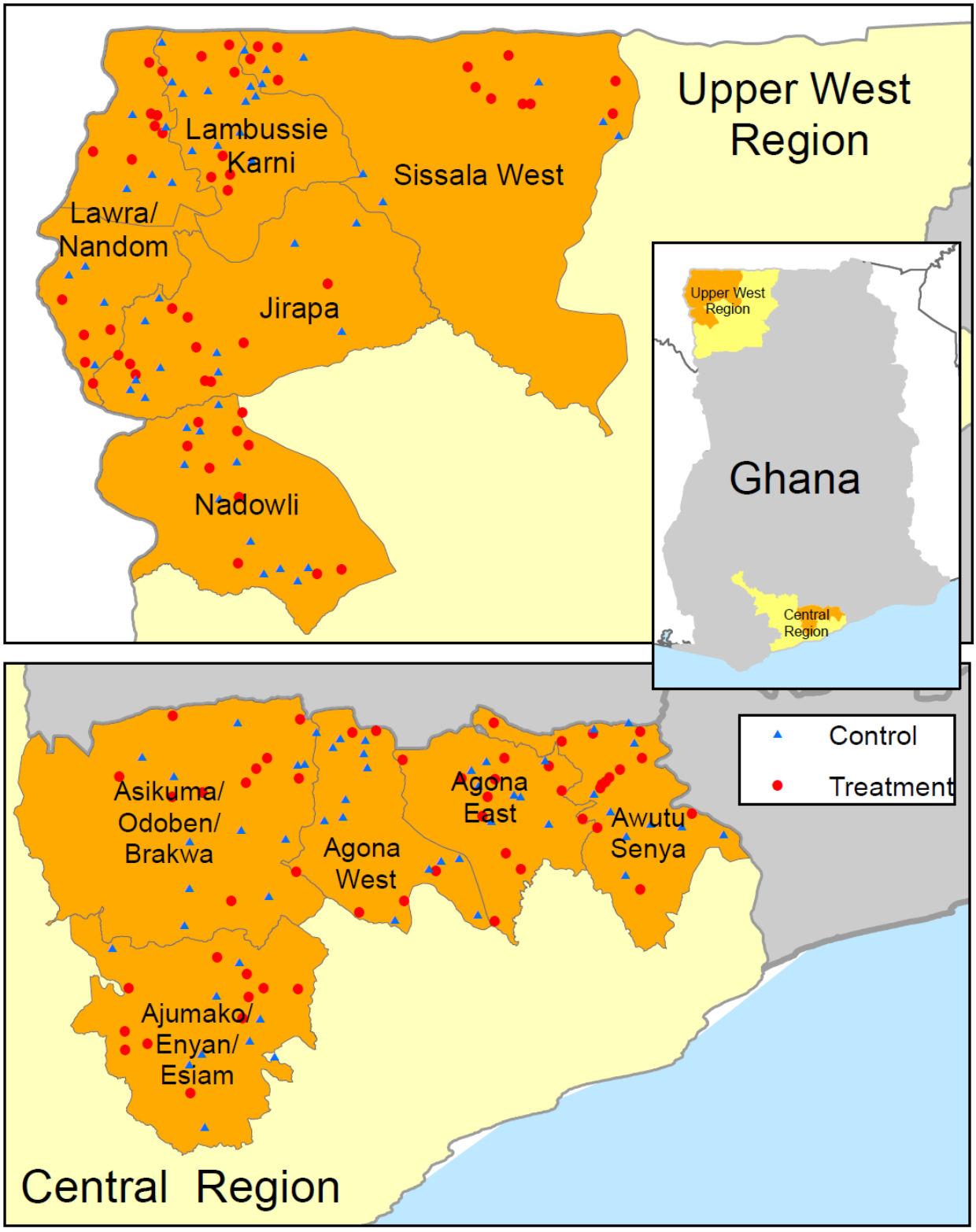
3.3.2 Sample size

Power calculations were conducted to estimate the necessary sample size required to measure a detectable effect of the VFC on two primary outcomes of interest: women's dietary diversity and agriculture production. The sample size estimation was based on the first-stage EA-level randomisation of the pooled encouraged groups to the comparison group. However, we also estimated the power for the given sample size for the second-stage household-level randomisation, in order to ensure that we were enabled to detect impacts across male- and female-targeted households. Because we used an encouragement design, the standard sample size calculations for cluster randomised control trials were amended to account for imperfect compliance (Glennerster and Takavarashi, 2013).

The inception report (Barnett *et al.,* 2017) and the baseline report (Billings *et al.*, 2018) provide more detail on the parameters used for the power calculations. Assuming the sample should be designed to detect a 15% increase in women's dietary diversity with a take-up gap of 45 percentage points between the encouraged group and the comparison group, the sample needed at baseline was 3,933 households across 207 EAs (19 households per EA). This sample size also ensured that we could detect an impact on cocoa yields if the take-up gap was 70 percentage points and the effect size was 35%. Using the actual take-up gap (to be found in Table 5.1) of 67% (the gap between encouraged and comparison households who signed up to the VFC service), we were powered to detect a 7.9% increase in women's dietary diversity, and a 38.8% increase in profits from cocoa.[12] When comparing male-targeted households to female-targeted households, we were powered at 97.5% to detect impacts of 15% (assuming a 45 percentage point take-up gap) on women's dietary diversity and at 81.5% to detect impacts of 35% (assuming a 45 percentage point take-up gap) on cocoa yields.[13]

[12] If instead we use a take-up gap of 34% (the gap between respondents who used the service in two groups, assuming no one in the control group used the service), the minimum detectable effects are 15.6% and 76.5% for women's dietary diversity and cocoa profits, respectively.
[13] These power calculations were conducted assuming no spillovers across households.

Figure 3.1: Map of study area



Source: Authors' own

3.4 Overview of baseline and follow-up surveys

3.4.1 Baseline and follow-up surveys (registration process)

The baseline survey was carried out between March and May 2017. In total, 3,936 households across 207 communities were interviewed for the baseline household survey. The baseline survey collected information on primary and secondary outcomes of interest related to dietary diversity, agriculture production, nutrition and farming knowledge, and mobile phone usage (see Billings *et al.* (2018) for more details).

The study encouragement intervention was implemented at the time of the baseline household data collection. Study households in communities randomised to the encouragement treatment assignment were offered the opportunity to become VFC members at the completion of the household survey. The targeted individual was informed about the VFC service through either an agriculture script or agriculture+nutrition script, and they were then asked to play a short game to determine the respondent's WTP for the service. In total, 91.5% of the encouraged households in treatment communities agreed to be registered for the VFC service.

Individuals who accepted the offer to become part of the VFC service were registered and profiled by enumerators. Registration required either migrating the existing Vodafone phone number of the respondent to VFC or providing the respondent with a new VFC SIM card. When possible, enumerators completed the registration in the respondent's home. Respondents were instructed to check the registration status of their SIM regularly and activate their SIM after it was registered by checking their balance, sending a text message, or making a call. In addition, enumerators collected all the information necessary to profile the respondents: language preference, preferred location, preferred markets, and a priority crop for agricultural tips. The enumeration team used this information to profile the registered and activated SIM cards.

To increase the likelihood that treatment households would register and activate their VFC subscription, enumerators were sent back to revisit all surveyed households in treatment EAs between July and August 2017. The household member initially targeted for being offered the VFC service was located, and s/he was asked a series of questions about whether s/he had activated their VFC membership, why s/he had elected not to go through the activation and profiling process (if s/he had not activated their VFC registration), and how s/he had interacted with the programme (if s/he had activated their VFC registration). Study participants that had not initially registered or activated their VFC membership were assisted through the registration and activation process.

3.4.2 Baseline balance

Besides providing summary statistics about the study sample, the baseline data allows us to empirically assess whether the randomisation of EAs to encouraged and comparison groups successfully created groups with similar characteristics at baseline. An imbalance in observable characteristics at baseline – especially those thought to be strongly correlated with the outcomes of interest – typically casts doubt on the ability of the evaluation to identify the causal effect of the intervention being investigated.

As detailed in the baseline report (Billings *et al.,* 2018), the randomisation successfully achieved baseline balance across the encouraged and comparison groups. Normalised differences between the encouraged and comparison groups were well below the 0.25 standard deviations cut-off that would indicate significant differences for baseline characteristics regarding demographics, wealth and assets, mobile phone access, dietary diversity, agriculture production, nutrition knowledge,

farming knowledge, and sources of information. Overall, from 208 tests of significant differences between the encouraged and comparison groups, only eight were significant. This is a rejection rate of 3.8%, a little less than what we should expect to find by chance.

Balance in baseline characteristics across male- and female-targeted households was not as successful in the subsample of households with both a primary male and primary female. Although none of the 190 normalised differences between the male- and female-targeted groups were above the 0.25 cut-off, 22 of the 190 tests of differences were significant. This is a rejection rate of 11.6%, which is more than what we should expect to find by chance. The differences in baseline characteristics are concentrated in demographics, the nutrition knowledge of males, and the farming knowledge of females. By estimating an ANCOVA model that controls for the baseline level of the outcome variable, we control for any initial imbalance across males and females.

3.5 Challenges and limitations

Below we discuss the challenges and limitations of the evaluation with respect to the study design and intervention.

One limitation with respect to the study design was the timing of the endline survey. Initially, the endline survey was set for March to May 2019, which would have been two years after the baseline survey to allow time for learning, changing behaviour and outcomes related to agriculture fully measured. However, this was moved forward to November 2018 given the high drop-out rates of study farmers and the likelihood that the service would end in the near future. November also seemed preferable because it was just after the harvest season. Unfortunately, harvest came late in 2018 and had not started for the Upper West region by November. As a result, the survey in the Upper West region was delayed to January 2019. This was not the case for the Central region, as harvest for most crops had finished. The exception was for cassava, where the harvest was also late. Thus, our agriculture estimates for the Central region may be biased downwards as one of its main crops had not yet been harvested

Another limitation of the study design relates to the external validity. While the randomised design ensures the internal validity of the study (i.e. that our impact estimates are not biased within our study sample), the external validity (i.e. that the study findings are representative of impacts on the overall rural population in Ghana) may be compromised in multiple ways. First, the sample for the evaluation was not designed to be representative of Ghana, but instead was designed to measure the impacts on the most relevant group of households. Inclusion criteria for households at the time of the CLE (before the study began) were that they had to: 1) be farming households; 2) own a mobile phone; 3) not be VFC members; and 4) have a primary female respondent aged 15–60 years old. Moreover, districts and EAs were selected into the sample based on: 1) the availability of Esoko market price information; 2) low VFC subscription rates; and 3) being within a 10 km radius of a Vodafone tower. EAs with fewer than 40 households were also excluded in order to ensure enough eligible households per EA. While many of these inclusion criteria were selected in order to maximise VFC usage, the impact of the VFC service will be on those most likely to access the service, which has implications regarding how much we can generalise our findings to the overall Ghana population.[14] Second, by randomly targeting the primary male or primary female, we are not necessarily targeting the owner of the phone or the main user. The study was designed in this way to increase the learning potential of the study and ensure we were better able to

[14] The exception is the inclusion criteria for EAs of having low VFC subscription rates. This was done in order to ensure that comparison EAs would have low subscription rates, giving the design a larger take-up gap between the encouraged and the comparison group.

understand the constraints female users face. However, we recognise that we were not necessarily targeting the main user.

Lastly, some aspects of the VFC service changed throughout the study period for the overall service but not for our study participants, which has implications for the external validity of the study and also demonstrates the challenges faced. One example is the changing price at which the VFC service was offered. It started at GHS 2 per month, then was lowered to zero (or free) to increase subscriptions, and then was set at GHS 0.50 per month. For farmers in our study, however, the price was always zero, and thus the type of user in our study may be different to the type of user that continued to use the VFC service once the price had increased to GHS 0.50. Similarly, the farmer profiling system changed over time. Initially, VFC agents conducted the profiling, and then Esoko, and then default profiling was implemented, until households called the helpline to change the defaults. For farmers in our study, however, the profiling was done by enumerators at baseline, and thus they never had the default profiling. Consequently, the profiling of our study farmers was likely more tailored to their needs compared to the default profiling. Lastly, the contract with Esoko to deliver recorded voice content for VFC was terminated before the study ended, although Esoko continued to operate the VFC helpline. For our study farmers, however, we continued to send the nutrition and agriculture voice messages throughout the endline data collection period. Thus, overall, our study farmers experienced a more consistent service delivery than a typical VFC farmer who was not included in our study.

4 Endline data collection

The endline data collection took place from November 2018 to March 2019 in two separate phases: from November to December in the Central region; and from January to March in the Upper West region. The decision not to do fieldwork in the two regions simultaneously was due to unusually late crop harvests in the Upper West region, leading to most crops not being harvested by the time that had initially been planned for the data collection. All fieldwork in the Upper West region was thus postponed by two months.

ISSER served as the in-country survey partner, leading the endline data collection in cooperation with the quantitative evaluation team from IFPRI. ISSER was chosen to be the partner for the baseline study due to its extensive experience conducting similar surveys in Ghana, and since the baseline fieldwork was completed successfully the cooperation was continued at endline.

4.1 Survey instruments

The endline household questionnaire was adapted from the baseline survey, which the IFPRI team designed based on the initial exploratory qualitative study (Barnett *et al.,* 2018), the landscaping review (Barnett *et al.,* 2016), and past experience conducting quantitative evaluations of agriculture and nutrition interventions in sub-Saharan Africa. The main modifications made to the endline questionnaire compared to the one used at baseline were the removal of the WTP module and the addition of two modules. One module included a digit span exercise randomly placed either early or late in the survey to test if survey fatigue caused recall bias;[15] the other included detailed questions on exposure to and experience with the VFC service.

The basic demographic information was pre-loaded from the baseline survey and not asked of members who were present in both periods; it was, however, collected for new household members. The rest of the questions were asked at both baseline and endline, including primary and secondary outcomes, predictive indicators for the outcomes, and intermediate outcomes relevant for testing different causal mechanisms. The full endline questionnaire can be found in Annex E.[16] The endline household interview took approximately an hour and 20 minutes to complete and required both the adult male ('primary male') and adult female ('primary female') to respond to the questionnaire. Primary female and primary male respondents were the same as were selected prior to the baseline survey from the listing exercise.[17] If a new household member was now in the role of a primary female/male, s/he was not surveyed in place of the primary male/female. That is, if a household with a missing primary male at baseline had a male present at endline, it was still surveyed as a single female household. In households with a single adult

[15] The endline household survey included a survey experiment within the interview to investigate the association between survey length and data quality. The idea was to test whether the survey length affected respondents' fatigue and their quality of recall. To do so, the order of asset and agriculture modules was randomised to come either towards the beginning or towards the end of the survey. Right before the assets or agriculture module, a quick cognitive test was administered using the forwards and backwards digit span test in order to see if survey length led to cognitive fatigue, and thus to recall bias.

[16] The GLSS 5, the 2015 Northern Ghana Agricultural Survey, and the 2008 Demographic and Health Survey were the basis for the instrument used for this survey.

[17] If the head of household was a female (male), they were selected as the primary female (male) respondent. If the head of household was a male (female) and married, the spouse of the head of household was selected as the primary female (male) respondent. If there were multiple spouses of the head of household, the primary female respondent was the highest order (earliest) wife. If the head of household was male (female) and unmarried, the primary female (male) respondent would be an adult female (male) who played a role in decision-making on farming and household expenditure and was 15 years or older.

female and no adult male, the modules for the primary male respondent were skipped, and vice versa.[18] Table 4.1 provides the list of modules and the target respondent for each module.

The final module of the survey – i.e. VFC service exposure and perceived quality – was administered to households in both encouraged and comparison EAs. However, the module was programmed such that subsequent questions were not asked once a respondent claimed not to have heard about the service or to have received any messages. The endline household survey questionnaires were administered by enumerators using Samsung tablets with a computer-assisted personal interview (CAPI) programmed in the Census and Survey Processing System. The CAPI enabled enumerators to easily access pre-loaded data, follow interview skip patterns according to interviewee responses, and back up survey data to a cloud server after each day of interviews.

[18] Households with no primary female at baseline were not eligible for the study. However, at endline households where the primary female was missing but the primary male present were still surveyed.

Table 4.1: Endline questionnaire modules

Module	Respondent
Module A: Household identification	Enumerator
Module B: Household composition	Primary male or next most responsible *Male or female*
Module C: Housing and assets	Primary male or next most responsible *Male or female*
Module D: Agriculture	Primary male or next most responsible for farming and agriculture *Male or female*
Module E: Access to credit	Primary male or next most responsible *Male or female*
Module F: Market information	Part 1: Primary male respondent Part 2: Primary female respondent
Module G: Mobile phone access and usage	Part 1: Primary male respondent Part 2: Primary female respondent
Module H: Nutrition knowledge	Part 1: Primary male respondent Part 2: Primary female respondent
Module I: Food security	Primary female respondent
Module J: Women's empowerment in agriculture	Primary female respondent
Module K: Farming knowledge and best practices	Part 1: Primary male respondent Part 2: Primary female respondent
Module L: Trust likelihood of nutrition and agriculture information	Randomised male OR female respondent from baseline
Module M: Digit span	Primary male or next most responsible *Male or female*
Module N: Exposure to the programme and usage	Randomised male OR female respondent from baseline, OR most knowledgeable adult with respect to VFC

Source: Authors' own

4.2 Ethics approval

As an overall guiding principle, the research team sought to conduct itself in a professional and ethical manner throughout the data collection and analysis phase, with strict respect for principles of integrity, honesty, confidentiality, voluntary participation, impartiality, and the avoidance of personal risk. These principles were informed by the Organisation for Economic Co-operation and Development (2010) Development Assistance Committee's Quality Standards for Development Evaluation and FCDO's (2011) 'Ethics Principles for Research and Evaluation'.

The ethical implications of the study were reviewed by three independent ethics committees (see Annex B). National-level ethics approval for both the quantitative and qualitative components of the study was obtained from the University of Ghana Ethics Committee for the Humanities on 10 October 2016 (prior to the start of baseline data collection) and reviewed annually (Annex B.1). In addition, ethics approval for the quantitative component was obtained from IFPRI's Institutional Review Board on 16 October 2016 (Annex B.2), again with an annual review, and the IDS Ethics Board provided approval for all components of the evaluation in September 2016 (Annex B.3)

The research was perceived as low risk by all ethics committees because the content generated was not sensitive, did not include particularly vulnerable groups (e.g. children), and was not

intrusive (e.g. it required no anthropometry or blood sample collection). No adverse events occurred through the course of the study and thus no reports were filed with the ethics committees.

Informed consent was collected from all research participants prior to the start of the endline interview. Informed consent included consent to access information on phone usage from the MNO. The entire field team was trained on ethical data collection prior to the start of the data collection.

All data files are securely stored in a password-protected database. Access to the data with individual identifiers is restricted to the IFPRI/IDS/Gamos evaluation team; however, anonymised data will be made publicly available within 12 months of final data collection on IFPRI's page at the Harvard Dataverse website.[19] Phone numbers collected during the baseline and follow-up surveys were used by the study team to locate households for the endline survey and the qualitative interviews, the delivery of VFC content once the Esoko/Vodafone contract had ended, and linking with administrative on usage of the service.

4.3 Fieldwork and household tracking

4.3.1 Endline survey enumerator team and training

ISSER, in close coordination with IFPRI, organised the endline survey enumerator training, which took place from 22 to 31 October 2018 on the University of Ghana campus in Accra. Forty-one enumerators were trained to administer the full endline survey through CAPI. Enumerators were selected according to experience and with language proficiency in Dagare or Twi, the local languages for Upper West and Central regions, respectively. Sixteen members of the enumeration team had also been involved in the baseline fieldwork. In-depth training was provided on all modules, including the gender-specific submodules and the digit spans exercise, with ample opportunity for practice in local languages. The training included one day of pre-testing on 30 October 2018 in a rural community outside of Accra for the Central region team. Due to the unusually late harvest in the north (mentioned above), data collection in the Upper West region was delayed by two months from the planned start date in November 2018 to January 2019. As a result, a four-day refresher training was held for the Upper West teams from 7 to 10 January 2019, including one day for pre-testing the survey in a rural village outside Wa.

4.3.2 Endline household data collection

Data collection for the endline household survey took place between 4 November 2018 and 13 December 2018 in the Central region, and between 13 January and 4 March 2019 in the Upper West region. Enumerators were grouped into eight teams of four enumerators and one supervisor. Four separate teams worked in the Central region and four in the Upper West region.

The teams were expected to conduct a total of 3,935 endline interviews, comprising 1,979 households in the Central region and 1,957 in the Upper West region. Endline interviews were to be conducted with the same households and the same primary male and primary female as at baseline. Enumerators were expected to follow certain procedures in the event of a missing household, a missing primary female, or a missing primary male. If one or the other was temporarily not available, enumerators were instructed to record the encounter in CAPI and attempt to schedule a revisit to the household. In cases where there was a permanently missing

[19] https://dataverse.harvard.edu/dataverse/IFPRI

female or male, enumerators marked down the reason and continued with the survey, skipping the sections specific to the missing primary male or primary female. If the entire household had moved, enumerators attempted to gain information about the new location from other community members. If a household had moved within one of the study districts (or was within reach, determined upon by consultation with the research coordinator), the enumerator attempted to find and interview the household in the new location. In the Central region only, a 'sweep' was conducted with a smaller team to attempt to revisit missing households or individuals not available during the main data collection period. A 'sweep' was not needed in the Upper West region given the high initial success at interviewing households.

The total number of households that completed the interview at endline was 3,802, or 96.6% of the baseline sample, indicating an attrition rate of 3.4% (Table 4.2). The main reason for baseline households not being interviewed was that no-one was available for an extended period, followed by a household not being found. Only eight households refused to be interviewed at endline. Of the 3,802 households in the final endline sample, 1,901 were in the encouraged group and 1,901 in the comparison group.

Table 4.2: Summary of household surveys in the Central and Upper West regions

	Central			Upper West			Total
	Encouraged	Comparison	Total	Encouraged	Comparison	Total	
Number of EAs completed	52	52	104	52	50	102	206
Baseline household interviews	991	988	1,979	988	969	1,957	3,936
Attempted endline household interviews[20]	991	987	1,978	988	969	1,957	3,935
Completed endline interviews	951	965	1,916	950	936	1,886	3,802
No-one available	26	15	41	29	23	52	93
Household not found	12	5	17	7	8	15	32
Refusal	2	2	4	2	2	4	8

Source: Authors' own

Of the 3,829 primary females interviewed at baseline, 3,555 were interviewed at endline: 1,775 in Central and 1,780 in the Upper West region (see Table 4.3). As such, the endline fieldwork captured 92.8% of primary females from the baseline, indicating an attrition rate of 7.2%. The main reason for a primary female not being interviewed was that the household was not interviewed, followed by the primary female no longer being part of the household (mainly due to divorce or death).

A total of 2,931 of the 3,185 primary males interviewed at baseline, or 92.0%, were interviewed at endline, indicating an attrition rate of 8%. The main reason for a primary male not being interviewed was that he was no longer part of the household (mainly due to death or long-term travel for work), followed by the household not being interviewed.

[20] At baseline one household was inadvertently interviewed twice, such that at endline the duplicate household was dropped, giving 3,935 attempted interviews.

Table 4.3: Summary of primary females and males surveyed at endline

	Primary female			Primary male		
	Central	Upper West	Total	Central	Upper West	Total
Primary male or primary female interviewed at baseline	1,917	1,911	3,828	1,495	1,690	3,185
Primary male or primary female completed interview at endline	1,775	1,780	3,555	1,370	1,561	2,931
Primary male or primary female temporarily migrated	11	12	23	14	11	25
Primary male or primary female no longer living in household	72	52	123	77	70	147
Household not surveyed at endline	58	67	127	34	48	82

Source: Authors' own

4.3.3 Testing for differential attrition at endline

Table 4.4 tests whether rates of attrition differ between the comparison and encouraged groups. We find that households in the comparison group are more likely than households in the encouraged group to be interviewed, and similarly the primary female in the comparison group is more likely than the primary female in the encouraged group to be interviewed. Although differences are marginally significant, they are small in magnitude and represent a 1.2 and 1.5 percentage point difference in attrition for the household and primary female, respectively.

Table 4.4: Attrition across encouraged and comparison arms

	Comparison mean	Encouraged mean	Treatment effect	N
Baseline household interviewed at endline	0.972	0.961	-0.012	3935
			(0.007)*	
Baseline primary female interviewed at endline	0.937	0.921	-0.015	3828
			(0.009)*	
Baseline primary male interviewed at endline	0.922	0.919	-0.003	3185
			(0.010)	

Note: Estimates from the mNutrition Ghana Endline Survey sample. Standard errors are in parentheses and clustered at the village level. Treatment effect reports the marginal effect on treatment from a probit regression of whether the household or individual was interviewed at endline on treatment variable, controlling for region. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

4.4 Data quality and cleaning

Data from the endline household surveys were collected using a Census and Survey Processing System program on Samsung tablets. All data were synched daily by enumerators (unless there were internet connectivity problems) to a remote, password-secure server in Dropbox.

ISSER and IFPRI were careful to ensure the quality of the data collection. This was done primarily in six ways. First, team supervisors travelled with the enumeration teams, sat in on interviews, and reviewed the data being collected. Second, a fieldwork manager was present for the first week of

household survey fieldwork, during which time he/she also sat in on household interviews, checked the data being recorded, and offered additional feedback to enumerators. Third, a fieldwork manager conducted EA revisits to address any issues that may have come up from the data collection teams. Fourth, ISSER concatenated and exported the baseline household data daily to Dropbox and checked for duplicate household identifiers and completeness of surveys. Fifth, ISSER kept detailed fieldnotes and communicated to IFPRI any issues in the field that needed to be resolved. Issues were discussed and solutions provided. Sixth, IFPRI conducted data validation checks at least three times a week on the exported data. To this end, a program to perform data checks was developed by IFPRI staff to promptly validate question responses and identify incomplete information through a set of consistency checks.

Incomplete or unsatisfactory questionnaires were returned to the relevant supervisors, and errors were corrected by enumerators during brief revisits to identified households or phone calls to respondents, if possible. The main problems included duplicate household identifiers, missing household heads, and missing primary male and primary female respondents identified at baseline study. In terms of the quality of data collection process, the main concern flagged was the short survey length. IFPRI and ISSER both therefore made continuous efforts to remind the enumerators not to rush through the surveys as doing so could negatively affect the data quality.

5 Experience with the VFC service

In this section, we discuss the findings from the core module of the endline survey: self-reported exposure and usage of the VFC; and the perceived quality of the service. The module was administered on all respondents regardless of their treatment arm, but the survey program was coded so that in cases where a respondent indicated that s/he did not know the VFC service or had not used it, subsequent questions would be skipped. We begin by presenting results on exposure and take-up of the service by treatment arm to see if there were differences across the encouraged and comparison arms. We then present results on use of the service by region and gender to see if usage and perceived quality differed either across region or across gender.

The module of exposure and usage was intended to be administered on the randomised primary male or primary female who was provided with the VFC information and invited to sign up at baseline. If the targeted individual was not available, however, the module was administered on the most knowledgeable adult (older than 15 years) with respect to VFC or mobile usage.[21] Given that many males responded to the module when the primary female was targeted, and vice versa, we look at experience with the programme by the gender of the respondent to the module and not the randomised targeted individual.

5.1 Exposure to the VFC service

Table 5.1 and Table 5.2 present the data on exposure to the VFC service across the intervention arms for the full sample and within the Central and Upper West regions, respectively. There is a clear difference between the encouraged group and the comparison group in terms of being aware of the service and having been signed up over the preceding one and a half years. Overall, 85.7% of households in the encouraged group had heard of VFC, compared to 14.8% of the comparison group. In addition, 68.2% of households in the encouraged group had signed up for the programme, compared to 1.2% of the comparison group, which translates to a take-up gap of approximately 67%. The take-up gap between the encouraged and comparison communities is consistent with our assumptions for our power calculations, which assumed a conservative take-up gap of 45% and an optimistic take-up gap of 70% (Barnett *et al.*, 2017). While 68.2% of households in the encouraged group had a member signed up at some point in the previous 18 months, only 26.7% of households had someone still signed up at the time of the endline survey – approximately 18 months after initial registration – which indicates high drop-out rates over time.

The regional breakdown in Table 5.2 shows that the exposure of the encouraged group is higher in the Upper West region. Within the encouraged group, 84.1% of households in the Central region indicated having heard of the programme, compared to 87.4% in the Upper West region; 62.8% of households in the Central region have a member who has been signed up over the previous 18 months, compared to 73.7% in the Upper West region; and 23.8% of households in the Central region have a member who was still signed up at the time of the endline survey, compared to 29.7% in the Upper West region. Take-up gaps (the difference between the encouraged and comparison groups) are large in both regions, at 62% in the Central region and 71% in the Upper West region.

[21] Among households where primary female was targeted, 20.9% of the endline interviews had a male responded for the program exposure module; among male-targeted households, 59.9% had a female respondent for the exposure module at endline.

Table 5.1: Exposure to VFC service, by treatment status

	N	Encouraged (E)	Comparison (C)	P-value
Knows VFC service	3,802	0.857	0.148	0.000
		(0.350)	(0.356)	
A household member is or has been signed up for VFC over the previous 18 months	3,802	0.682	0.012	0.000
		(0.466)	(0.109)	
A household member is currently signed up with VFC	3,802	0.267	0.002	0.000
		(0.443)	(0.046)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means between the encouraged and the comparison group.

Source: Authors' own

Table 5.2: Exposure to VFC service, by region and treatment status

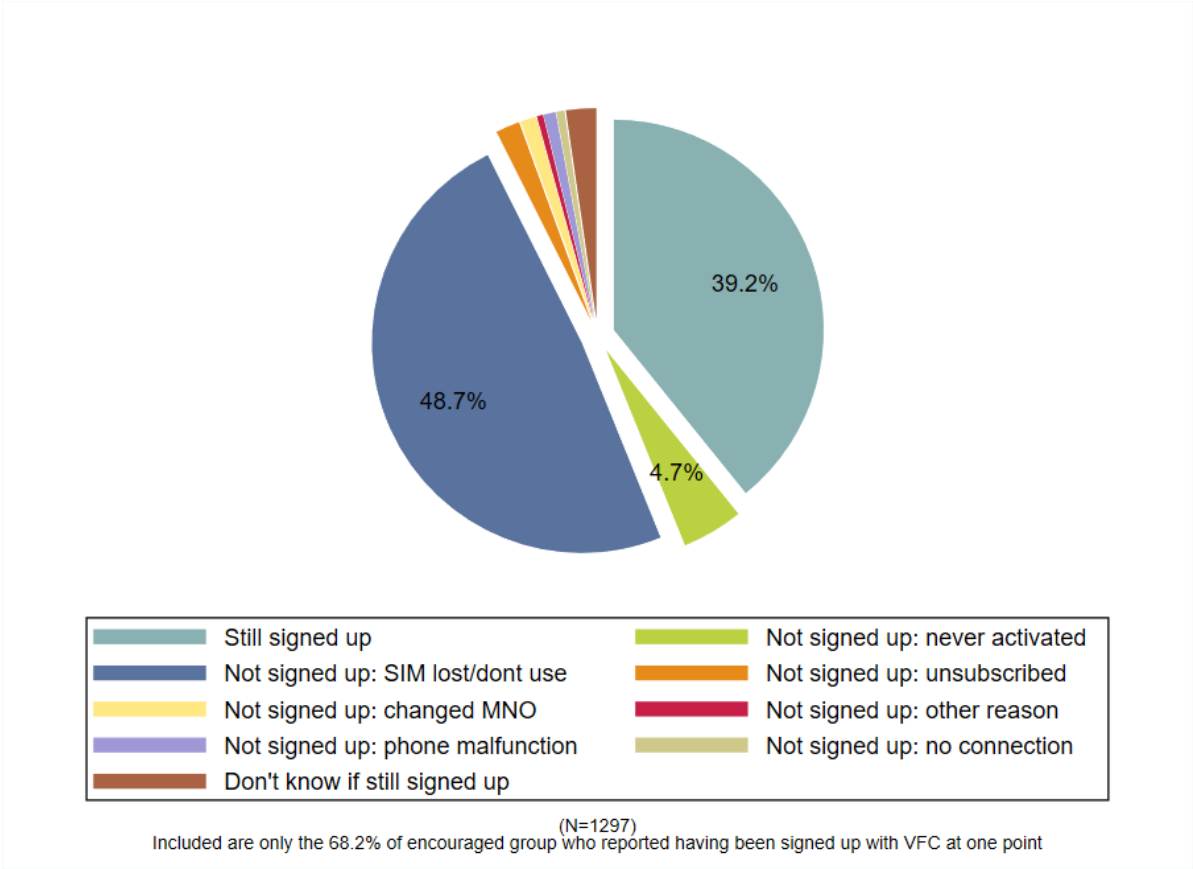
	Central				Upper West			
	N	Encouraged (E)	Comparison (C)	P-value	N	Encouraged (E)	Comparison (C)	P-value
Knows VFC service	1,916	0.841	0.158	0.000	1,886	0.874	0.139	0.000
		(0.366)	(0.364)			(0.332)	(0.346)	
A household member is or has been signed up for VFC over the previous 18 months	1,916	0.628	0.001	0.000	1,886	0.737	0.024	0.000
		(0.484)	(0.032)			(0.441)	(0.152)	
A household member is currently signed up with VFC	1,916	0.238	0.001	0.000	1,886	0.297	0.003	0.000
		(0.426)	(0.032)			(0.457)	(0.057)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means between encouraged and comparison group within a respective region.

Source: Authors' own

The current VFC participation status of the 68.2% of encouraged households with a member that had been signed up at one point over the past 18 months is shown in Figure 5.1. We can see that 39.2% of households indicate that they are still signed up, while the rest (60.8%) indicate that they are not signed up or do not know if they are still signed up. The most common reason for no longer being signed up is not using the SIM or losing it (48.7%), followed by having never activated the service (4.7%).

Figure 5.1: Status of households' VFC subscription



Source: Authors' own

5.2 Interaction with the VFC platform

5.2.1 Use of the VFC service

We next look at individual respondents' use of the service for households where a member has been signed up at one point over the past 18 months. Given that very few comparison households signed up for the service, we restrict the analysis to the encouraged group. Table 5.3 reveals that half of the respondents (49.8%) from households that have been signed up to the programme have used the service over this time period and the other half have not.[22] While there are no significant differences across regions, there are significant differences across gender: 63.2% of male respondents had used the VFC service in the previous 18 months, compared to 42.9% of female respondents. Among respondents that state that they have not used the service in the previous 18 months, the most common reason is losing the SIM or not using the SIM (62.5%), followed by

[22] Questions on the use of the service are asked of the individual respondent: 'Have you, (name of individual) used the Vodafone Farmer's Club service in the previous 18 months (to either make or receive calls, send or receive SMS, receive agriculture or nutrition information, receive weather or market price information, call the help line)?'

having no phone access (24.0%), and phone malfunction (10.4%). Of note is that very few households report not using the service because of too many messages or because they do not find it useful. The largest difference in the reason for not using the VFC service between female and male respondents is having no phone access: 32.2% of females and only 12.3% of males state this as the reason for not using the service, which is significant at the <1% level. Males are significantly more likely than females to state that they had not used the service due to losing or not using the SIM. Across regions, people in the Upper West region are significantly more likely than those in the Central region to report phone malfunction or no access to a phone as a reason for not using the VFC service, and are less likely to report poor connectivity. The questionnaire also included an 'Other' option, in which case a respondent was asked to specify the reason they had not used the service. Multiple respondents specified that the 'other' reason is that their phone can only use one SIM card. This aligns with findings from the baseline qualitative study that showed there to be a lot of multi-SIM behaviour and manual SIM switching (Barnett *et al.*, 2017). We can presume that this kind of behaviour also applies to a proportion of the respondents who indicated losing the SIM or not using it.

Table 5.4 reports usage statistics for respondents that have used the service in the previous 18 months. Of the 646 respondents that used the service in the previous 18 months, 61.5% are still signed up and there are no differences across region or gender. When asked whether they had received the agriculture and market price message on their desired commodity, 67.2% reported that they did receive this information. Similarly, 72.8% reported that they had received messages in their desired language. Again, there are no differences across gender or region. These statistics show that the system of profiling individuals to their desired commodity and language was not perfect, even when this information was manually entered by hand, as was the case for the study participants here.

Table 5.3: Usage of VFC service within encouraged group, by region and respondent's gender

	N	All	Central	Upper West	P-value	Female respondent	Male respondent	P-value
Has used VFC service in the previous 18 months	1,297	0.498	0.515	0.475	0.433	0.429	0.632	0.000
		(0.500)	(0.500)	(0.500)		(0.495)	(0.483)	
Hasn't used the service because of too high a price	651	0.003	0.007	0.000	0.148	0.004	0.000	0.156
		(0.055)	(0.083)	(0.000)		(0.064)	(0.000)	
Hasn't used the service because of bad connectivity	651	0.058	0.093	0.042	0.009	0.049	0.099	0.100
		(0.235)	(0.291)	(0.201)		(0.217)	(0.299)	
Hasn't used the service because of service not being useful	651	0.005	0.007	0.003	0.463	0.006	0.000	0.086
		(0.068)	(0.083)	(0.051)		(0.078)	(0.000)	
Hasn't used the service because of too many messages	651	0.009	0.010	0.008	0.820	0.006	0.019	0.226
		(0.096)	(0.101)	(0.089)		(0.078)	(0.135)	
Hasn't used the service because of better offers	651	0.002	0.000	0.003	0.320	0.002	0.000	0.320
		(0.039)	(0.000)	(0.051)		(0.045)	(0.000)	
Hasn't used the service because of phone malfunction	651	0.104	0.079	0.129	0.083	0.101	0.117	0.580
		(0.306)	(0.271)	(0.336)		(0.301)	(0.323)	
Hasn't used the service because of a lack of phone access	651	0.240	0.197	0.277	0.059	0.322	0.123	0.000
		(0.427)	(0.398)	(0.448)		(0.468)	(0.330)	
Hasn't used the service because of not knowing about it	651	0.023	0.024	0.024	0.868	0.023	0.025	0.880
		(0.150)	(0.154)	(0.152)		(0.149)	(0.156)	
Hasn't used the service because of losing/not using the SIM	651	0.625	0.610	0.636	0.557	0.620	0.722	0.056
		(0.484)	(0.489)	(0.482)		(0.486)	(0.449)	
Hasn't used the service for another reason ('other')	651	0.088	0.124	0.055	0.005	0.035	0.000	0.000
		(0.283)	(0.330)	(0.229)		(0.184)	(0.000)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means: 1) between Central and Upper West regions; and 2) between female and male respondents. Included in the first row are households in the encouraged group that have been signed up for VFC over the previous 18 months.

Source: Authors' own

Table 5.4: Language and commodity preference, by region and respondent's gender

	N	All	Central	Upper West	P-value	Female respondent	Male respondent	P-value
Is currently using (signed up for) VFC service	646	0.615	0.601	0.627	0.493	0.601	0.633	0.394
		(0.487)	(0.491)	(0.484)		(0.490)	(0.483)	
Receives agricultural and price information on desired commodity and market	646	0.672	0.653	0.691	0.386	0.691	0.647	0.288
		(0.470)	(0.477)	(0.463)		(0.463)	(0.479)	
Receives voice messages in a language that they understand	646	0.728	0.724	0.732	0.825	0.721	0.737	0.638
		(0.446)	(0.448)	(0.444)		(0.449)	(0.441)	

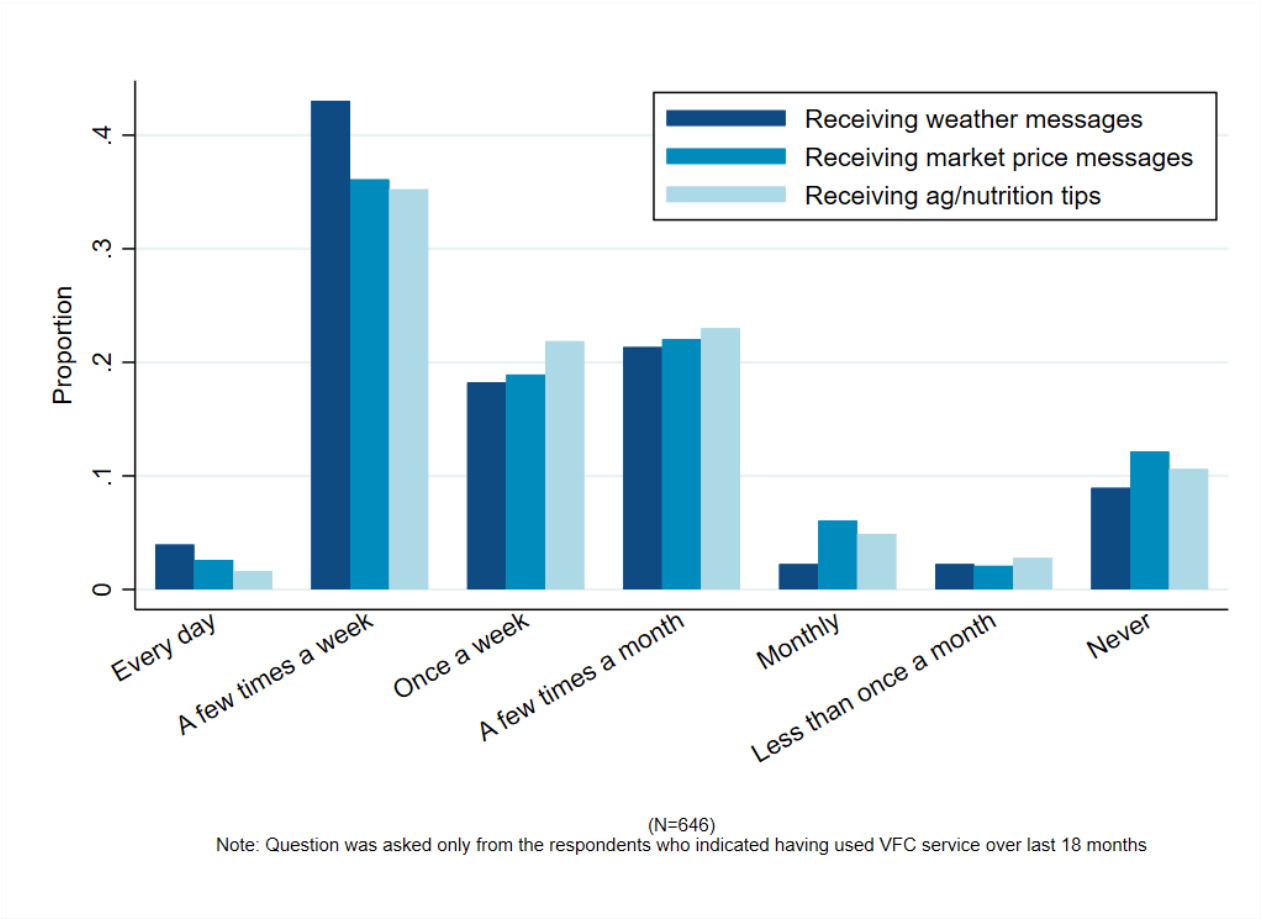
Note: Estimates from the mNutrition Ghana endline survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means: 1) between Central and Upper West regions; and 2) between male and female respondents. Included are respondents from the encouraged group who indicated using the service over the preceding 18 months.

Source: Authors' own

5.2.2 Use of the different components of the VFC service

At endline, we asked respondents how often they received and read or listened to the different components of the VFC service, conditional on having used the service once in the previous 18 months. Figure 5.2 reveals that, consistent with the weekly schedule of messages sent, the most commonly reported frequency for receiving messages was 'a few times a week': 42.7% reported receiving weather information a few times a week, 35.9% reported receiving market price information a few times a week, and 35.2% reported receiving agricultural and nutrition tips a few times a week. The proportion of respondents who indicated that they were active subscribers of the service but did not receive a particular message type is about 8% for messages with weather information, 11% for messages with market price information, and 10% for messages with agricultural and nutrition tips.

Figure 5.2: Frequency of receiving the different components of VFC

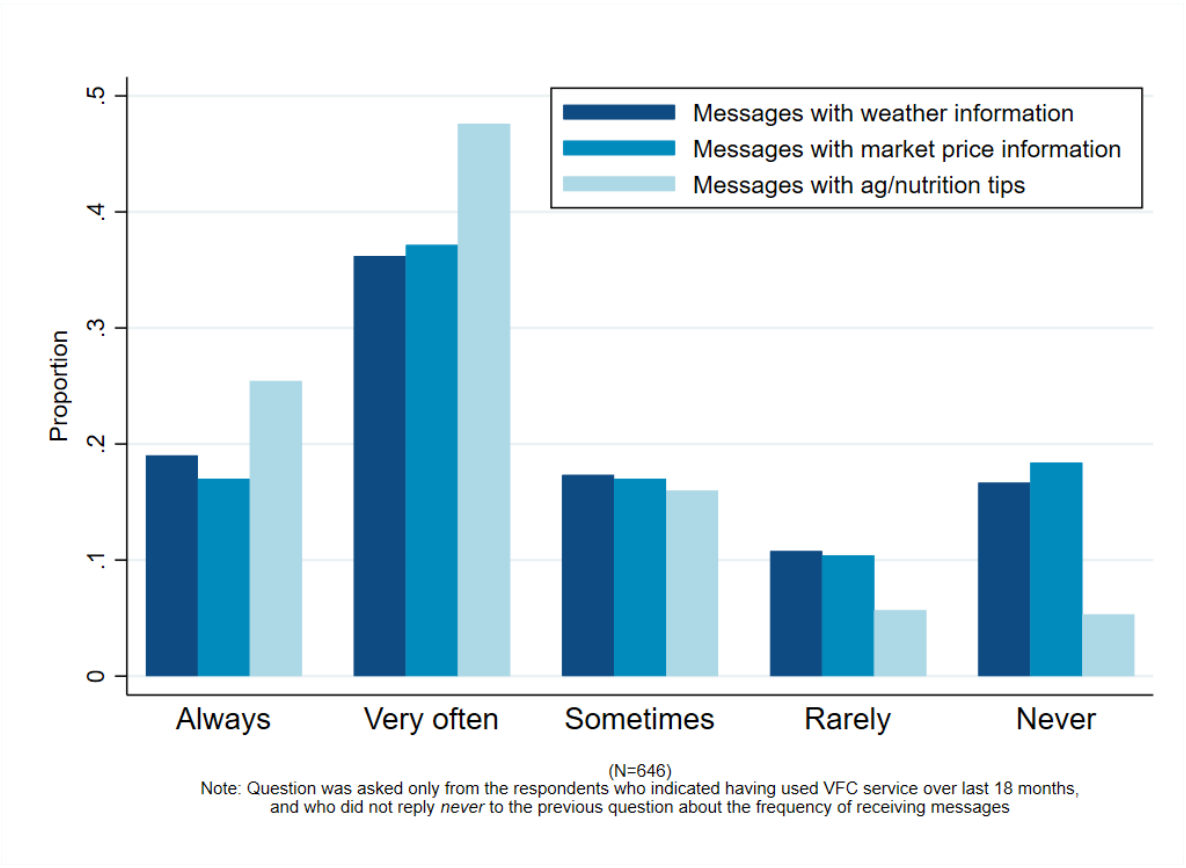


Source: Authors' own

Although most respondents reported receiving weather, market price, and agriculture and nutrition messages, they may not have actually read or listened to all the messages. Figure 5.3 reveals that among respondents who used the VFC service at least once in the previous 18 months, only 55.4% read the weather messages always or very often, 54.2% read the market price messages always or often, and 73.0% listened to the agriculture and nutrition voice messages always or often. Also, 27.4% and 28.8% of respondents reported rarely or never reading the market price or weather messages, respectively, and 10.9% of respondents reported rarely or never listening to the agriculture and nutrition voice messages. Thus, respondents were engaging more actively with

the agriculture and nutrition voice messages, compared to the weather and market price SMS messages.

Figure 5.3: Frequency of reading/listening to received messages

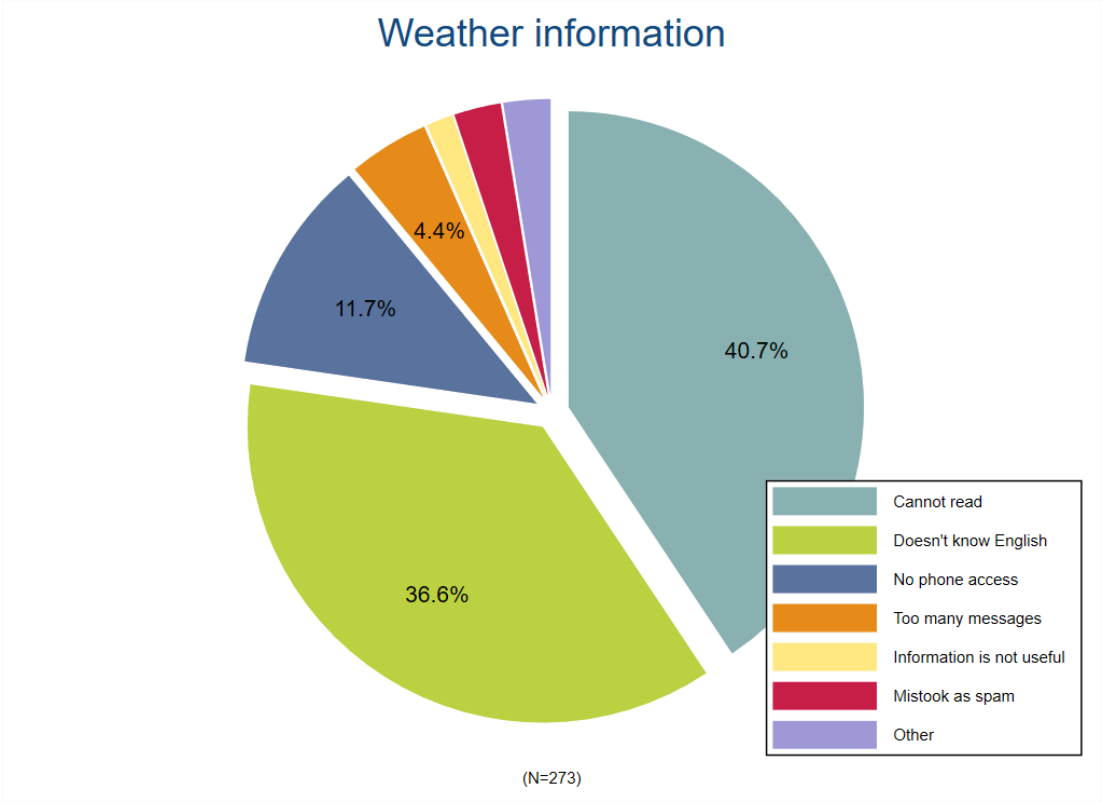


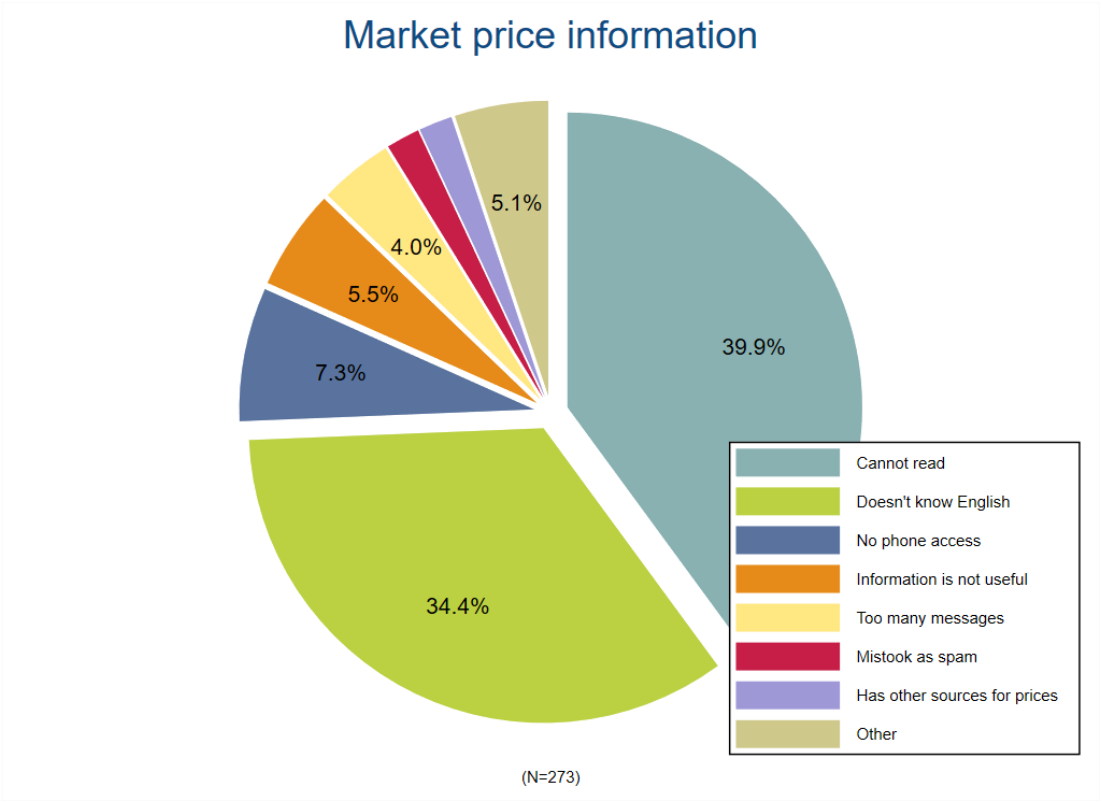
Source: Authors' own

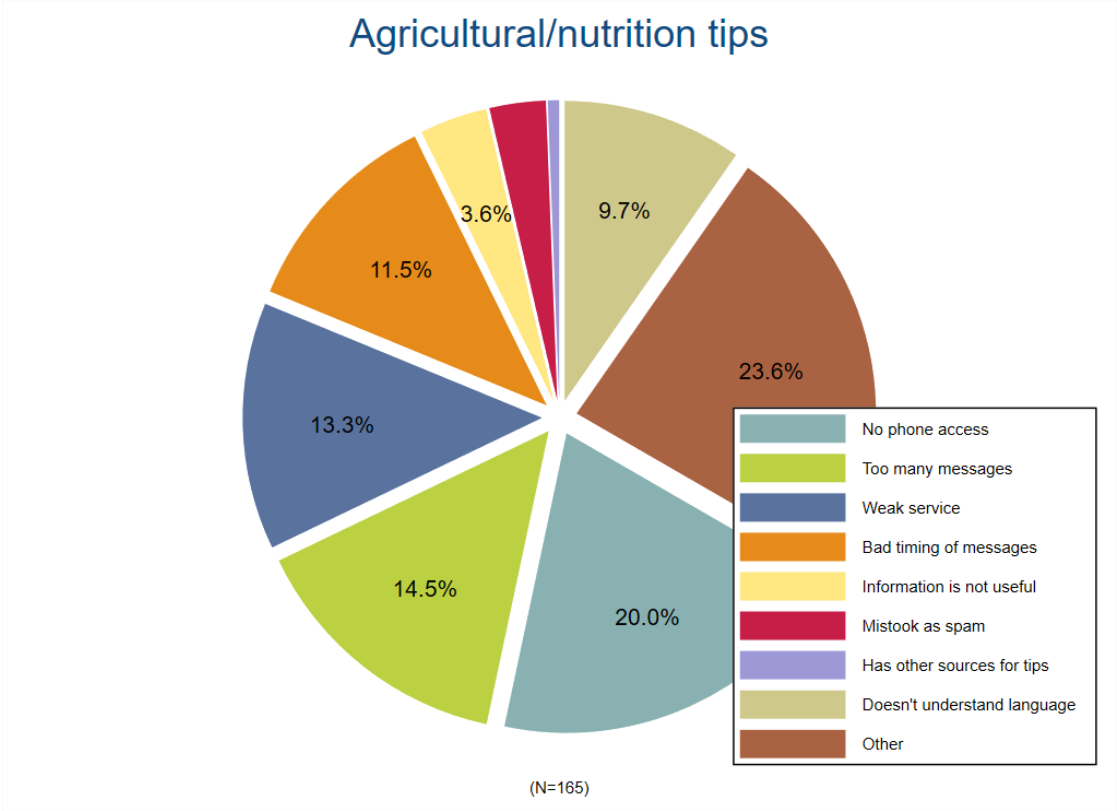
More detail on the usage of the different components of the VFC service – i.e. weather information, market price information, agricultural and nutrition tips, and farmer helpline – among the individuals who have used the service at one point over the previous 18 months can be found in Table 10.1 of Annex D. Among the individuals who have used VFC service at one point, 36.2% had used the helpline to speak with an agricultural expert. There are noticeable regional differences in exposure to the content: respondents in the Upper West region are significantly more likely to have received messages with weather information (97.1% versus 86.0% in the Central region), market price information (94.5% versus 82.8%), and agricultural and nutrition tips (94.2% versus 85.4%).

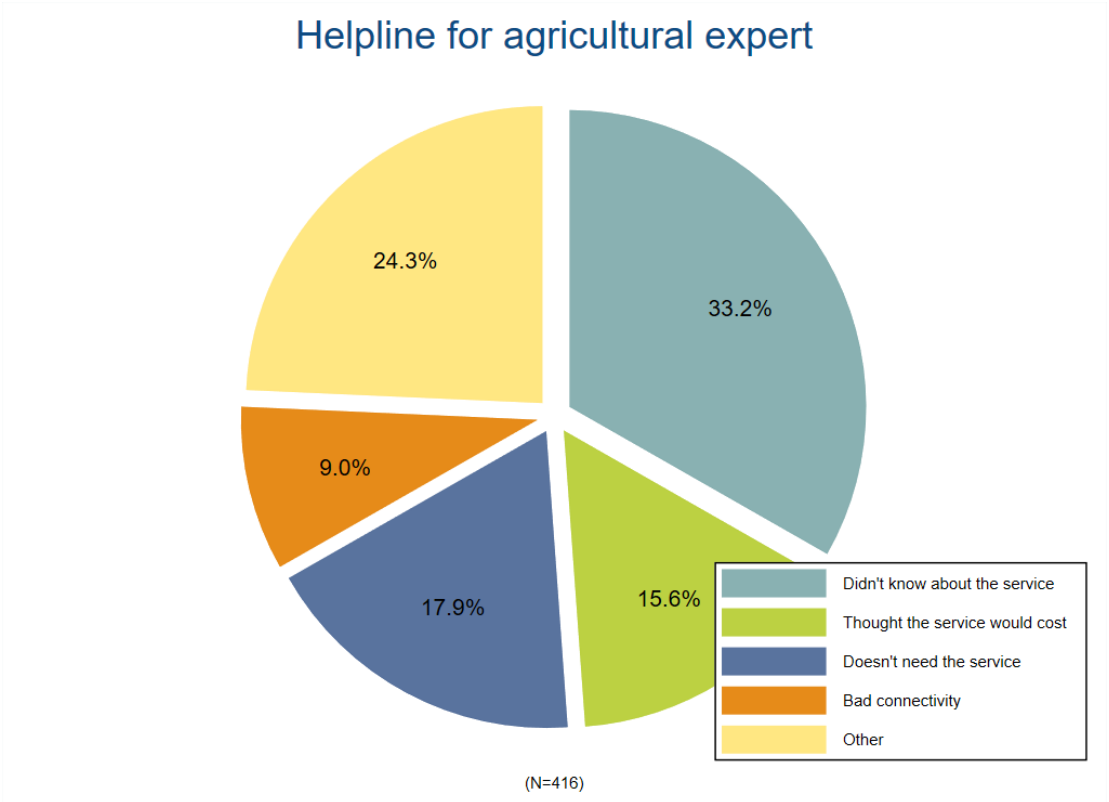
As can be seen in Figure 5.3, not all respondents are actively reading or listening to the messages. The main reason for not often reading or listening vary by component (Figure 5.4). For weather and market price information, which was delivered via SMS in English, the main reasons are not being able to read or not knowing English. For agriculture and nutrition tips, which were delivered via voicemail in the local language, the main reason was weak service, too many messages, and not having access to a phone. For using the helpline to speak with an agriculture agent, the main reason for not using the service was not knowing that it was available, followed by not needing to use it, and believing that there was a charge for the service.

Figure 5.4: Reported reasons for not reading or listening to the VFC messages, by service component









Source: Authors' own

There are large differences across region and gender in reading or listening to messages (Table 10.1 in Annex D). In particular, people in the Upper West region are more likely than those in the Central region to not always or often read or listen to the weather, market price, or agriculture and nutrition messages. In part, this is due to people in the Upper West region being more likely than

those in the Central region to report not being able to read the messages and not having phone access. Central region residents are more likely than those in the Upper West region to report not reading market price information or listening to agriculture and nutrition voice messages because they are not useful. In terms of gender differences, although rates of reading or listening to messages do not differ, the reasons for not reading or listening do differ across male and female respondents. In particular, female respondents are more likely than male respondents to report not reading the weather or market price information because they cannot read, and not listening to voice messages because they do not have access to a phone. Male respondents are more likely than female respondents to report not reading messages because there are too many of them (weather) or because they are not useful (market price).

Overall, these results suggest that voice messages in the local language represent a better platform than SMS in English for delivering content, especially in the Upper West region or to female respondents where illiteracy rates are higher, but that there are still barriers to the usage of voice messages. They also suggest that not all components of the service were well known and understood; this applies in particular to the farmer helpline.

5.3 Perceptions of the service

The following section discusses satisfaction with the VFC service as reported by those individuals who had used it over the previous 18 months.

Even though respondents do not listen to or read all messages, the majority of respondents that have received the messages indicate that they find them useful, that it has changed their behaviour, and that they trust and feel confident in the information (Table 5.5). These rates range from 51% finding the market price information useful, to 72% finding the agriculture and nutrition tips useful, to 96% finding the advice from the agriculture expert useful. Similarly, 50% of respondents state that the market price information has led to a change in behaviour, while 75% state that they have put in practice the agriculture and nutrition tips. Furthermore, 63.5% of respondents state that they trust the market price information, compared to 80.9% of respondents stating they trust the agriculture and nutrition messages and 94.4% stating they trust the advice of the agriculture expert.

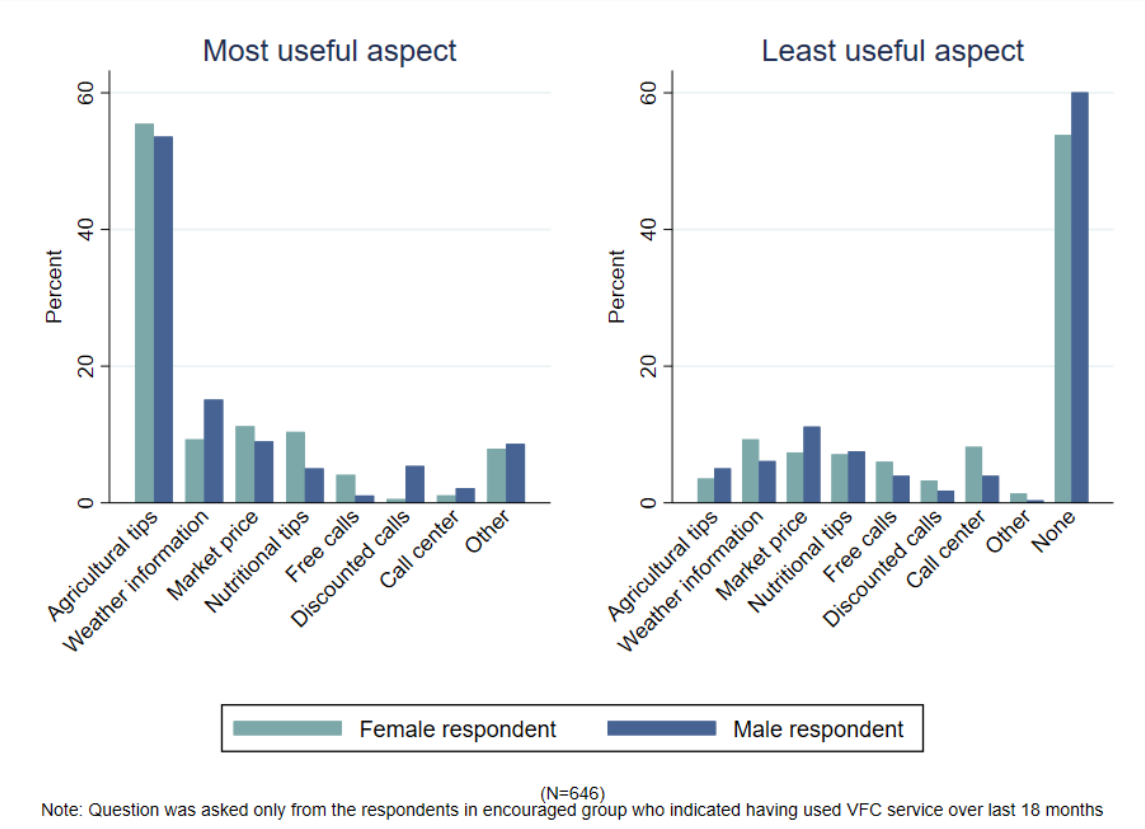
Respondents in the Central region were more likely to find the messages useful, with 63.8% in the Central region and 51.1% in the Upper West always or very often finding weather messages to be useful, and 78.7% in the Central versus 66.9% in the Upper West region always or very often finding messages with agriculture and nutrition tips useful. Across gender, females are more likely to state that market price information leads to changes in farming practices (52.9% versus 46.2% of respondents, respectively), while males are more likely to trust and feel confident in advice provided by VFC on agriculture (97.1% versus 92.2%). Overall, these results suggest that the most useful and trusted component was the helpline for obtaining agriculture expert advice, but this was the least used and known component.

Respondents who had used the VFC were asked to identify the most and least useful functions of the service, and to rate the quality of different aspects of the service. Figure 5.4 and Figure 5.5 show both the most useful and the least useful functions of the VFC service as reported by users, broken down by respondent gender and region, respectively. Figure 5.5 reveals that agricultural tips are the most useful aspect by a wide margin: 55.5% of females and 53.6% of males identify it as such. This is followed by weather information (9.3% of females and 15.1% of males) and market price information (11.2% of females and 9.0% of males).

Nutritional tips are identified as the most useful only by 10.4% of females and 5% of males, with the difference being statistically significant at 5% level (Table 5.6). A potential reason for the low rates of respondents finding the nutrition information the most useful is that farmers do not necessarily recognise the difference between the nutrition and agriculture tips since both were delivered via voice message. The most common response to the question about the least useful aspect was 'None', with 53.8% of females and 60.1% of males choosing this. The second and third most popular answers were market price information (9% of respondents) and weather information (8% of respondents).

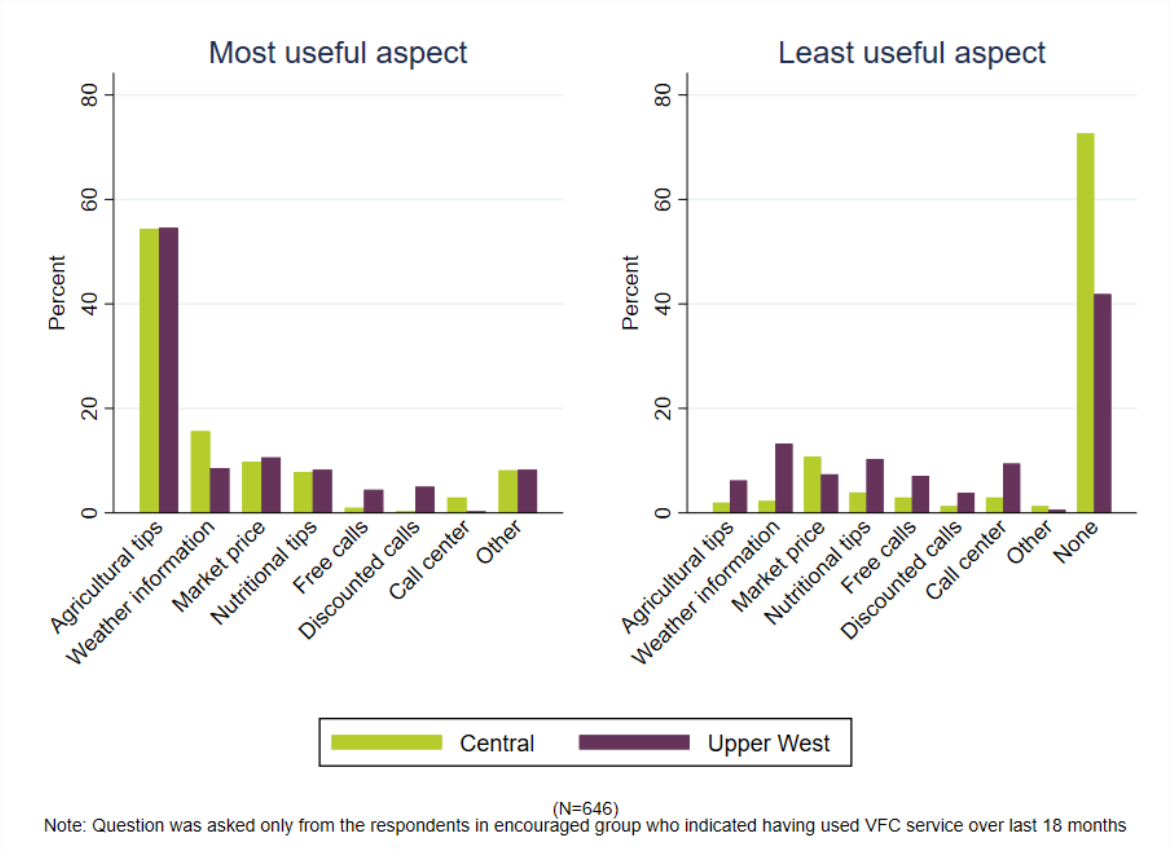
There are noticeable regional differences, which can be seen in Figure 5.6. The largest gap is between the proportions of respondents who identified 'None' as the least useful aspect: 72.7% in the Central region and 42.0% in the Upper West region, which is statistically significant at the 1% level (Table 5.6). In the Upper West region, the proportions of respondents who identified an aspect of a programme to be the least useful were significantly higher than the Central region for each component, with the exception of marker price information. This is consistent with Table 5.5, which reveals that the Upper West region is less likely than the Central region to find the messages useful.

Figure 5.5: Most and least useful aspect of the VFC service, by gender



Source: Authors' own

Figure 5.6: Most and least useful aspect of the VFC service, by region



Source: Authors' own

Table 5.5: Usefulness of different types of VFC content within encouraged group, by region and respondent's gender

	N	All	Central	Upper West	P-value	Female respondent	Male respondent	P-value
Weather information								
Always or very often found the messages with weather info useful	594	0.566	0.638	0.511	0.002	0.553	0.588	0.424
		(0.496)	(0.482)	(0.501)		(0.498)	(0.493)	
Weather information led to changes in farming practices/behaviour	594	0.650	0.675	0.631	0.321	0.649	0.652	0.947
		(0.477)	(0.469)	(0.483)		(0.478)	(0.477)	
Agrees that they trust and feel confident in weather information provided by VFC	594	0.692	0.717	0.673	0.307	0.675	0.716	0.301
		(0.462)	(0.451)	(0.470)		(0.469)	(0.452)	
Market price information								
Always or very often found the messages with market price info useful	576	0.512	0.522	0.506	0.729	0.535	0.486	0.257
		(0.500)	(0.501)	(0.501)		(0.500)	(0.501)	
Market price information led to changes in farming practices/behaviour	576	0.498	0.490	0.506	0.771	0.529	0.462	0.055
		(0.500)	(0.501)	(0.501)		(0.500)	(0.500)	
Agrees that they trust and feel confident in market price information provided	576	0.635	0.584	0.676	0.067	0.642	0.628	0.714
		(0.482)	(0.494)	(0.469)		(0.480)	(0.484)	
Agriculture and nutrition tips								
Always or very often found the messages with agriculture and nutrition tips useful	582	0.723	0.787	0.669	0.008	0.735	0.715	0.649
		(0.448)	(0.410)	(0.471)		(0.442)	(0.452)	
Has put into practice some of the agriculture and nutrition tips from the messages	582	0.749	0.772	0.731	0.257	0.759	0.742	0.699
		(0.434)	(0.420)	(0.444)		(0.428)	(0.438)	
Agrees that they trust and feel confident in agriculture and nutrition tips provided	582	0.809	0.814	0.808	0.854	0.790	0.840	0.169
		(0.393)	(0.390)	(0.394)		(0.408)	(0.367)	
Helpline – Agricultural expert								
Found advice from the agriculture expert useful	234	0.962	0.943	0.982	0.140	0.946	0.981	0.173
		(0.193)	(0.233)	(0.133)		(0.227)	(0.137)	
Agrees that they trust and feel confident in advice provided by VFC agricultural expert	234	0.944	0.927	0.964	0.264	0.922	0.971	0.083
		(0.230)	(0.261)	(0.186)		(0.268)	(0.167)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means: 1) between Central and Upper West regions; and 2) between male and female respondents. Included are respondents from the encouraged group who indicated using the service over the preceding 18 months.

Source: Authors' own

Table 5.6: Most and least useful aspects of the service, by region and respondent's gender

	N	All	Central	Upper West	P-value	Female respondent	Male respondent	P-value
VFC most useful aspect: agriculture tips	646	0.545	0.542	0.548	0.969	0.555	0.536	0.632
		(0.498)	(0.499)	(0.498)		(0.498)	(0.500)	
VFC most useful aspect: weather information	646	0.119	0.159	0.085	0.023	0.093	0.151	0.044
		(0.324)	(0.366)	(0.279)		(0.291)	(0.359)	
VFC most useful aspect: market prices	646	0.102	0.097	0.105	0.754	0.112	0.090	0.336
		(0.303)	(0.297)	(0.307)		(0.316)	(0.287)	
VFC most useful aspect: nutritional tips	646	0.080	0.078	0.082	0.831	0.104	0.050	0.016
		(0.272)	(0.268)	(0.274)		(0.305)	(0.219)	
VFC most useful aspect: free calls	646	0.028	0.010	0.047	0.049	0.041	0.011	0.000
		(0.165)	(0.098)	(0.211)		(0.199)	(0.104)	
VFC most useful aspect: discounted calls	646	0.028	0.003	0.050	0.010	0.005	0.054	0.007
		(0.165)	(0.057)	(0.217)		(0.074)	(0.226)	
VFC most useful aspect: call centre/helpline	646	0.015	0.029	0.003	0.023	0.011	0.022	0.380
		(0.124)	(0.169)	(0.054)		(0.104)	(0.146)	
VFC most useful aspect: other	646	0.082	0.081	0.082	0.966	0.079	0.086	0.726
		(0.275)	(0.274)	(0.274)		(0.270)	(0.281)	
VFC least useful aspect: agriculture tips	646	0.042	0.019	0.061	0.017	0.036	0.050	0.357
		(0.200)	(0.138)	(0.240)		(0.185)	(0.219)	
VFC least useful aspect: weather information	646	0.080	0.023	0.131	0.000	0.093	0.061	0.174
		(0.272)	(0.149)	(0.338)		(0.291)	(0.240)	
VFC least useful aspect: market prices	646	0.090	0.107	0.073	0.183	0.074	0.112	0.154
		(0.286)	(0.310)	(0.260)		(0.262)	(0.315)	

VFC least useful aspect: nutritional tips	646	0.073	0.039	0.105	0.005	0.071	0.076	0.866
		(0.260)	(0.194)	(0.307)		(0.257)	(0.265)	
VFC least useful aspect: free calls	646	0.051	0.029	0.070	0.024	0.060	0.040	0.225
		(0.220)	(0.169)	(0.255)		(0.238)	(0.195)	
VFC least useful aspect: discounted calls	646	0.026	0.013	0.041	0.023	0.033	0.018	0.230
		(0.160)	(0.113)	(0.198)		(0.178)	(0.133)	
VFC least useful aspect: call centre/helpline	646	0.063	0.029	0.093	0.004	0.082	0.040	0.032
		(0.244)	(0.169)	(0.291)		(0.275)	(0.195)	
VFC least useful aspect: other	646	0.009	0.013	0.006	0.399	0.014	0.004	0.070
		(0.096)	(0.113)	(0.076)		(0.116)	(0.060)	
VFC least useful aspect: none	646	0.565	0.727	0.420	0.000	0.538	0.601	0.185
		(0.496)	(0.446)	(0.494)		(0.499)	(0.491)	

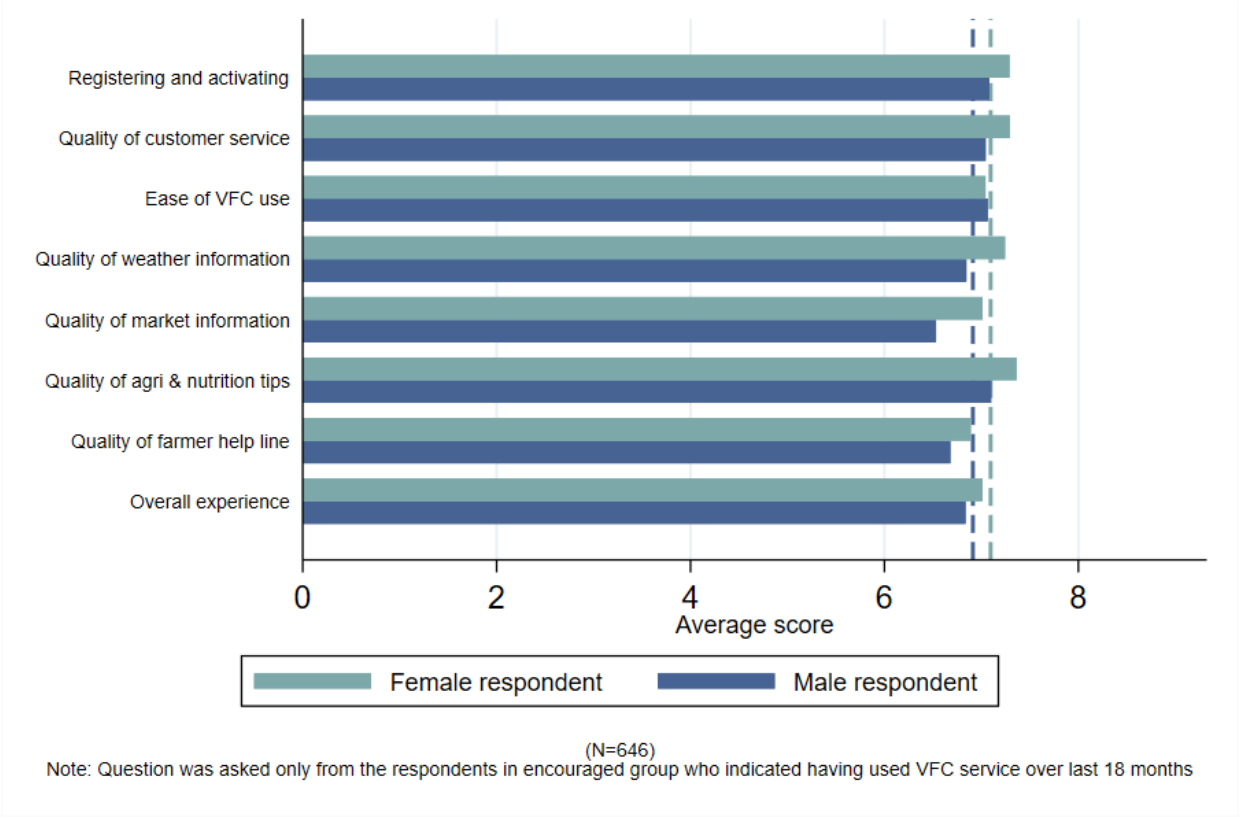
Note: Estimates from the mNutrition Ghana Endline Survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means: 1) between Central and Upper West regions; and 2) between female and male respondents. Data collected only if a respondent was using or had been using VFC over the previous 18 months.

Source: Authors' own

Figure 5.7 and Figure 5.8 show the overall ratings of the quality of service by gender and region. Ratings were on a scale from 1 to 10, with 1 being very low and 10 being very high. The average score for the respondents' overall experience with the VFC service was 7 for females and 6.8 for males. The highest quality ratings by both genders were given to agricultural and nutrition tips, at 7.10 points by males and 7.36 points by females. Females gave statistically higher ratings than males for the quality of market price information and the quality of the weather information (see Table 10.2 in Annex D).

Figure 5.8 reveals that there are regional differences in reported quality scores, with ratings being higher in the Central region than in the Upper West in every category. The average score for the respondents' overall experience with the VFC service is 7.37 in the Central and 6.69 in the Upper West region, which is significant at the 1% level. The gap is the biggest for the perceived quality of customer service (a 0.89-point difference) and ease of VFC use (a 0.89-point difference).

Figure 5.7: Reported quality scores, by gender



Source: Authors' own

Figure 5.8: Reported quality scores (1–10), by region

Source: Authors' own

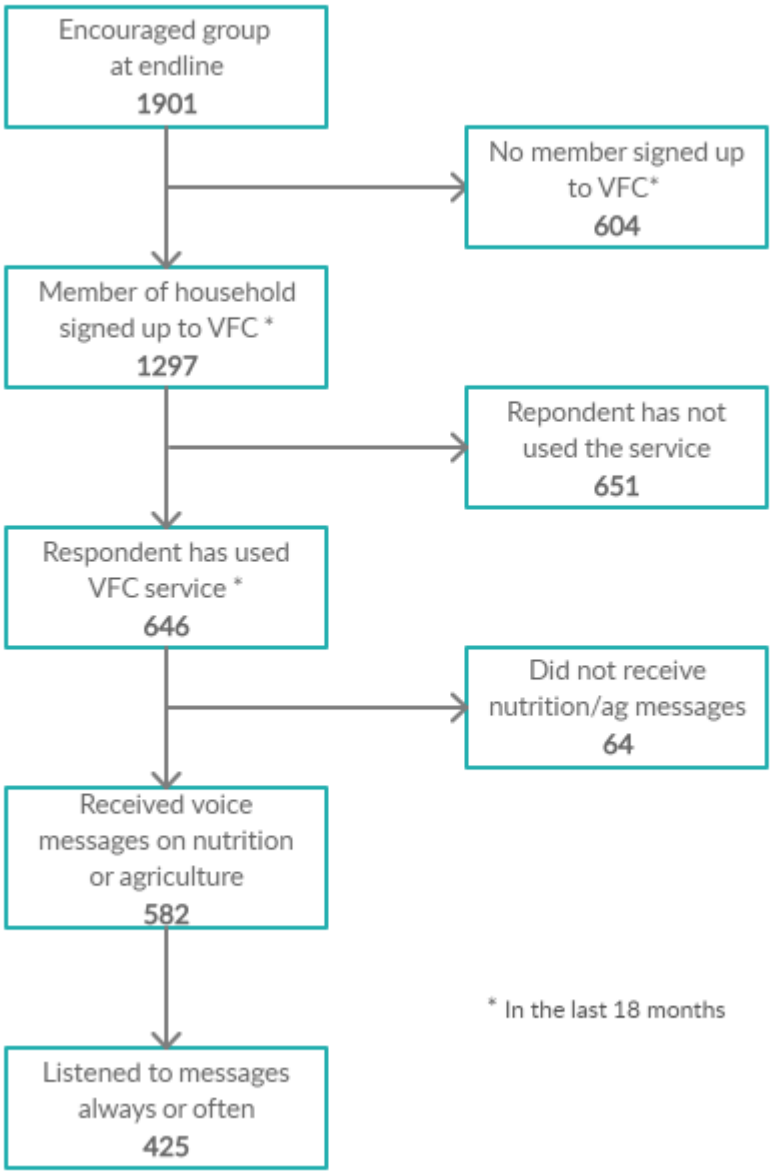
5.4 Summary

In this section we have reported on households' exposure to and take-up of the VFC service, individuals' interaction with and use of the service, and their perceptions of it. We find high rates of take-up among households in the encouragement group, demonstrating that the encouragement was successful. However, not all households that registered for the service were still registered at the time of the endline survey and not all households had used the service. Thus, of the 1,901 households in the encouragement group at endline, 68% (or 1,297 households) had registered for the service over the previous 18 months and 27% were still signed up at the time of the endline survey. Of households that had registered for the service, 49.8% (or 646 households) had used the service in the previous 18 months. This means that only 34% of encouragement households used the service in the previous 18 months. These registration rates are higher in the Upper West region than in the Central region, and usage rates are significantly higher among male respondents compared to female respondents. The main reason for not using the service is losing or not using the SIM, followed by not having access to a mobile phone, the latter reason being significantly higher in the Upper West region and among female respondents. This is consistent with the qualitative findings that showed multiple SIM usage to be a potential barrier to use (Barnett *et al.,* 2017).

Even across households that report using the service in the previous 18 months, individuals may not receive all components of the service or they may not interact with all components of the service. Between 8% and 11% of respondents that report using the service report never having received a message with market price, weather, or agricultural/nutrition information, and among those that receive the messages not all actively read or listen to them. Thus, 27.4% and 28.8% of respondents report rarely or never reading the market price or weather messages, respectively, and 10.9% of respondents report rarely or never listening to the agriculture and nutrition voice

messages. Thus, the proportion of encouraged households that are *active* participants in the service is quite low (see Figure 5.9). While people in the Central region are less likely to receive messages compared to those in the Upper West region, they are more likely to read the messages if received.

Figure 5.9: Interaction with VFC platform within the encouraged group



Source: Authors' own

The reasons for not actively interacting with the platform vary by content. For weather and market price information, which was delivered via SMS in English, the main reasons for not reading all the messages are not being able to read or not knowing English. For agriculture and nutrition tips, which were delivered via voicemail in the local language, the main reasons are weak service, too many messages, and not having access to a phone. For speaking with an agriculture agent, the main reasons for not using the service are not knowing that it was available, followed by not needing to use the service, and believing that there was a charge for the service. These barriers

are consistent with the qualitative midline findings (Barnett *et al*., 2019), which found that the same barriers led to low engagement with the service.

The reasons for not actively engaging with the platform vary by region and gender. People in the Upper West region are more likely than those in the Central region to report not being able to read the market price or weather messages and not listening to the nutrition/agriculture voice message because they do not have phone access. People in the Central region are more likely than those in the Upper West region to report not reading market price information and not listening to agriculture/nutrition voice messages because they are not useful. In terms of gender differences, female respondents are more likely than male respondents to report not reading the weather or market price information because they cannot read, and not listening to voice messages because they do not have access to phones. Male respondents are more likely than female respondents to report not reading messages because there are too many (weather) or they are not useful (market price). Overall, these results suggest that voice messages in the local language represent a better platform than SMS in English for delivering content, especially in the Upper West region or to female respondents where illiteracy rates are higher, but that there are still barriers to the usage of voice messages. They also suggest that not all components of the service – especially the farmer helpline – were well known and understood.

Although active participation among the encouraged households is low, respondents' perceptions of the service were quite favourable. The majority of respondents that have received messages indicate that they find the content of the VFC service useful, that it has changed their behaviour, and that they trust and feel confident in the information. Overall, the most useful and trusted component was the agriculture expert advice offered through the helpline, but this was the least used and known component. Respondents in the Central region were more likely to find the messages useful than were respondents in the Upper West region.

Agriculture tips are identified as the most useful component of the VFC service, while the least useful is 'None', with respondents the Central region identifying 'None' more often than those in the Upper West region. Quality ratings on eight different aspects of the VFC service are assessed and receive a score of around 7/10. The average score for respondent's overall experience with the VFC service was 7 for females and 6.8 for males. The highest quality ratings were given to agricultural and nutrition tips. Females gave statistically higher ratings than males for the quality of market price information and the quality of the weather information. There are regional differences in reported quality scores, with ratings being higher in the Central region than in the Upper West in every category.

Overall the reasons for not using the service seem to be related more to practical issues such as multiple SIM use, literacy, phone access, and network connectivity, than to not finding the messages useful. This is consistent with the favourable perceptions and opinions on the information provided, and also consistent with the qualitative work, which gives examples of how farmers used the messages (Barnett *et al*., 2019). One important caveat, however, is that we only have the reasons for non-use for a select sample that registered for the service, and the opinion and perceptions for a select sample that used the service. Thus, we do not know if those that did not end up using the service would have had different opinions and perceptions about the content.

6 ITT impact estimates

In this section, we assess the impact of the VFC on primary and secondary outcomes identified prior to the evaluation. Our analysis follows the empirical specification detailed in Section 3. Thus, using an ANCOVA model we estimate the ITT effect as the difference in average outcomes between the comparison group and those that were assigned to the randomised encouragement group, regardless of whether they had actually participated in VFC. That is, we measure the impact of treatment assignment (in this case, encouragement to participate in VFC) on the outcomes of interest. For all the outcomes, we present the endline mean of the comparison group and the ITT estimate with basic controls and extended controls. Basic control variables include an indicator for the region and the value of the respective outcome at baseline. Extended controls include household size, whether the household head is female, whether the household head is literate, a poverty index,[23] whether the household owns a working mobile phone,[24] and the order of survey modules. The coefficients reported in the impact estimate columns, taken together with their standard errors, indicate both the magnitude of the estimated impact of being offered the VFC service and whether the estimated impact is statistically significant.

The primary outcomes of the study are household and women's dietary diversity, agricultural yields, and income from agriculture. Improvements in these outcomes are the main objective of mNutrition in mAgri programmes. The secondary outcomes are participants' knowledge, and market access and practices. In regard to the latter, we analyse both primary females' and males' nutrition-related knowledge, farming-related knowledge, and market access and practices as assessed by the endline survey questionnaire. VFC provides both nutrition and farming information via voice messages and SMS texts in order to change farmers' behaviour, and thus we assess whether farmers' knowledge and practices have improved as a result of the information provided.

6.1 Primary outcomes

6.1.1 Household dietary diversity

We construct a household dietary diversity index using information collected on the food the household consumed in the 24 hours prior to the survey. For 21 different food items, respondents were asked 'Yesterday (during the day or the night) did anyone in your household eat or drink any [food item]?' This information is used to construct a Household Dietary Diversity Score (HDDS), which combines responses to the 21 food items consumed into the following 12 food groups: cereals, roots/tubers, vegetables, fruits, meat/poultry/offal, eggs, fish/seafood, pulses/legumes/ nuts, milk/milk products, oils/fats, sweets, and spices/condiments/beverages. The HDDS indicates a household's economic access to food, and thus the score includes items that require household

[23] To measure household wealth, we rely on the Poverty Probability Index (PPI). This uses a country- and year-specific set of 10 questions to calculate the likelihood that a household is living below different national and international poverty lines. A higher PPI score corresponds to a lower likelihood of the household living below the poverty line. In Ghana, the 10 questions used to generate the PPI involve: the number of household members; the school enrolment of children in the household; whether the male head or spouse could read a phrase in English; the building materials used for the walls; the type of toilet facility; the fuel used for cooking; ownership of a working box or electric iron, a working TV, video player, VCD player, or satellite dish; the number of working mobile phones owned by the household; and ownership of a working bicycle, motorcycle, or car. The latest index was created in 2015 using GLSS 6. See www.progressoutofpoverty.org/ for a more detailed description of the methods.

[24] While owning a mobile phone was part of our inclusion criteria, we find at baseline that about 90% of households do not own a working mobile phone. This could be due to the fact that the community listing exercise, where we identified households, occurred a month or two before the baseline data collection.

resources to obtain, such as condiments, sugar and sugary foods, and beverages (Kennedy *et al.*, 2011).

Table 6.1 reports the comparison group's mean score and the ITT impacts on HDDS. Households, on average, consumed 5.88 out of 12 food groups in the last 24 hours. Condiments, cereals, and seafood are the most commonly consumed groups (91.9%, 90.1%, and 85.5%, respectively), while the least common are eggs, dairy, and sweets (10.7%, 13.0%, and 17.8%, respectively). Under the basic control model, there are no impacts of being offered the VFC service on the HDDS or the individual food group indicators. The extended control model reveals similar results, although the impact on consuming dairy is now marginally significant.

Table 6.1: ITT estimates of VFC on household dietary diversity

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
HDDS (1–12)	5.878	0.069	0.052	3706
		(0.095)	(0.093)	
Household consumed cereals	0.901	0.012	0.011	3796
		(0.013)	(0.013)	
Household consumed roots and tubers	0.534	0.023	0.021	3778
		(0.017)	(0.017)	
Household consumed vegetables	0.665	0.014	0.012	3795
		(0.022)	(0.022)	
Household consumed fruit	0.667	-0.018	-0.021	3789
		(0.026)	(0.026)	
Household consumed meat/organ meat	0.209	0.023	0.021	3779
		(0.017)	(0.016)	
Household consumed eggs	0.107	0.009	0.008	3782
		(0.011)	(0.011)	
Household consumed seafood	0.855	-0.015	-0.015	3793
		(0.018)	(0.018)	
Household consumed legumes, pulses, nuts, and seeds	0.305	0.000	-0.003	3792
		(0.022)	(0.022)	
Household consumed dairy	0.130	0.023	0.023*	3796
		(0.014)	(0.014)	
Household consumed oils and fats	0.413	-0.010	-0.011	3758
		(0.022)	(0.022)	
Household consumed sweets	0.178	0.007	0.004	3749
		(0.017)	(0.017)	
Household consumed condiments	0.919	0.011	0.010	3781
		(0.011)	(0.011)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an Ordinary Least Squares (OLS) regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

6.1.2 Women's dietary diversity

Individual food consumption of the primary female was also collected and used to construct the Minimum Dietary Diversity – Women (MDD-W) score. The MDD-W is a dichotomous indicator that equals 1 when women consume at least five out of 10 food groups, a level that reflects the greater likelihood of women meeting their micronutrient needs than women consuming foods from fewer food groups (FAO and FHI 360, 2016). Like the HDDS, the survey instrument collected information on 21 different food items consumed by the primary female in the last 24 hours. For each food item the primary female was asked, 'Did you, (name of primary female respondent), eat or drink any [food item] yesterday (during the day or night)?' (See Annex E for the full module.)[25] Responses from the 21 food items were used to create indicators on the primary female's consumption of the following 10 food groups: grains/white roots/tubers, pulses, nuts and seeds, dairy, meat/poultry/fish, eggs, dark green leafy vegetables, other vitamin A-rich fruits and vegetables, other vegetables, and other fruit.[26] In contrast to the HDDS, the MDD-W does not include oils/fats, sweets, and spices/condiments/beverages, but instead is composed of 10 food groups intended to reflect the micronutrient adequacy of the diet (Kennedy *et al*., 2011).

Table 6.2 reveals the comparison's group mean score and the ITT estimates of being offered the VFC service on MDD-W. At endline, the primary female, on average, consumed 4.3 food groups out of 10, and only 50% of women met the minimum dietary diversity of consuming at least five food groups. As with the household results, almost all women had consumed tubers and grains (98.3%) in the last 24 hours, most had consumed meat, fish, and poultry (88.3%), and very few had consumed eggs (8.5%), dairy (10%), or nuts and seeds (10.1%). Under both the basic control and extended control model, there are no impacts on the MDD-W or on individual food groups of being offered the VFC service.

Table 6.2: ITT estimates of VFC on women's dietary diversity

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Women's Dietary Diversity Score (1–10)	4.338	-0.045	-0.053	3553
		(0.086)	(0.084)	
Met MDD-W	0.500	-0.018	-0.020	3553
		(0.027)	(0.027)	
Primary female consumed tubers and grains	0.983	-0.008	-0.009	3572
		(0.007)	(0.006)	
Primary female consumed pulses	0.188	-0.011	-0.012	3567
		(0.016)	(0.016)	
Primary female consumed dairy	0.100	0.008	0.009	3572
		(0.013)	(0.012)	
Primary female consumed meat/fish/poultry	0.883	-0.013	-0.012	3572
		(0.015)	(0.015)	

[25] Guidelines for the MDD-W (FAO and FHI 360, 2016) state two methods for collecting food group indicators: open recall and list-based. While open recall is recommended, the guidelines acknowledge the advantages and disadvantages of each method. We chose the list method because it was logistically more feasible to implement in terms of CAPI programming and enumerator training.

[26] Unfortunately, the survey instrument did not separate out the categories 'other vegetables' and 'other fruit', instead combining these into one question. We deal with this problem by considering anyone who answered 'yes' to 'other fruits and vegetables' in the survey to have consumed both 'other fruits' and 'other vegetables'.

Primary female consumed eggs	0.085	-0.000	-0.000	3567
		(0.011)	(0.011)	
Primary female consumed green leafy vegetables	0.623	-0.010	-0.011	3569
		(0.024)	(0.024)	
Primary female consumed vitamin A-rich fruits and vegetables	0.139	0.013	0.010	3571
		(0.016)	(0.016)	
Primary female consumed other vegetables	0.616	-0.016	-0.018	3571
		(0.026)	(0.026)	
Primary female consumed other fruits	0.616	-0.016	-0.018	3571
		(0.026)	(0.026)	
Primary female consumed nuts and seeds	0.101	0.013	0.010	3566
		(0.014)	(0.013)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

6.1.3 Agricultural production and income

The outcomes we analyse for agricultural production are separated into crop diversity, area cultivated, and yields (Table 6.3), as well as the value of production, input costs, and profits (Table 6.4). We construct indicators for total agriculture production in addition to crop-specific agriculture production. The crop-specific indicators are for maize, which is grown in both the Upper West and Central regions; cocoa, which is grown in the Central region; and groundnut, which is grown in the Upper West region. Most of these indicators were constructed at baseline as well, and exact details on how they were constructed can be found in the baseline report (Billings *et al.*, 2018). For indicators on area cultivated and yields we take the log value, which transforms these indicators into a normal distribution and lessens the impact of outliers. For indicators on value of production, input costs, and profits, we take the inverse hyperbolic sine (HIS) instead of log values because it is able to transform negative numbers. The analysis is conducted on all households that report owning or managing agricultural land, which make up 98% of the sample.

Table 6.3 reveals that households on average cultivated 2.77 crops in the last major season and the total area under cultivation was on average 1.7 log acres, which is 6.7 acres. Most households grow maize (72.4%), 30.6% of households cultivate cocoa, mainly in the Central region, and approximately 32% of households cultivate groundnut, mainly in the Upper West region (see Section 8.2 for results across region). With the exception of a marginally significant decrease in the area of cocoa cultivated, there are no impacts of being offered VFC on crop diversity, area cultivated, or yields.

Table 6.3: ITT estimates of VFC on crop cultivation

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Number of crops cultivated	2.774	0.073	0.057	3737
		(0.079)	(0.077)	
Total area cultivated (acres) (log)	1.718	-0.014	-0.024	3622
		(0.039)	(0.039)	
Household grows maize	0.724	0.025	0.022	3737
		(0.019)	(0.019)	
Area of maize cultivated (acres) (log)	0.989	0.009	0.003	2765
		(0.030)	(0.030)	
Yield of maize (kg/acre) (log)	5.314	0.019	0.009	2734
		(0.070)	(0.069)	
Household grows cocoa	0.296	-0.019	-0.021	3737
		(0.020)	(0.020)	
Area of cocoa cultivated (acres) (log)	1.586	-0.086	-0.094*	1046
		(0.055)	(0.054)	
Yield of cocoa (kg/acre) (log)	3.209	-0.023	-0.019	1035
		(0.184)	(0.184)	
Household grows groundnut	0.311	0.014	0.014	3737
		(0.018)	(0.018)	
Area of groundnut cultivated (acres) (log)	1.051	-0.005	-0.019	1191
		(0.030)	(0.030)	
Yield of groundnut (kg/acre) (log)	5.021	-0.082	-0.073	1169
		(0.079)	(0.076)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone – and order of survey modules. The control mean is the comparison group's mean at endline. Variables of yield are screened for outliers before taking the log value: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Although there are no impacts of being offered VFC on yields, there may be impacts on income from agriculture production if farmers are able to obtain better market prices and thereby increase the value of production or decrease input costs. Table 6.4 reveals that there are no statistically significant impacts of being offered the VFC service on either the total value, input costs, or profit. This applies to both outcomes for individual crops and aggregate indicators, and the outcome is robust to the addition of extended controls to the model. The average total value of production in the last major season has an IHS of 7.5, which translates to GHS 4,081.2 (approximately US$ 760). The production of cocoa has the highest value, input costs, and profits across the three crops.

Table 6.4: ITT estimates of VFC on value, costs, and profits (GHS) of crop production

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Total value of production (IHS)	7.544	-0.065	-0.097	3591
		(0.119)	(0.116)	
Total input costs (IHS)	6.616	0.038	0.023	3593
		(0.098)	(0.096)	
Total profit (IHS)	3.384	-0.007	-0.101	3562
		(0.344)	(0.334)	
Total value of maize produced (GHS) (IHS)	6.603	0.018	0.001	2731
		(0.080)	(0.081)	
Input cost of maize (IHS)	5.714	0.008	0.010	2736
		(0.115)	(0.114)	
Profit from maize (IHS)	2.257	0.019	-0.051	2714
		(0.316)	(0.314)	
Total value of cocoa produced (IHS)	6.871	-0.186	-0.190	1034
		(0.347)	(0.350)	
Input cost of cocoa (IHS)	5.953	-0.103	-0.080	1038
		(0.198)	(0.199)	
Profit from cocoa (IHS)	3.949	0.232	0.205	1025
		(0.563)	(0.554)	
Total value of groundnut produced (IHS)	6.668	-0.082	-0.079	1181
		(0.104)	(0.102)	
Input cost of groundnut (IHS)	5.215	-0.022	-0.029	1180
		(0.233)	(0.236)	
Profit from groundnut (IHS)	2.896	-0.615	-0.632	1170
		(0.436)	(0.427)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone – and order of survey modules. The control mean is the comparison group's mean at endline. Variables of value of production and cost of production are screened for outliers before taking the IHS transformation: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

6.2 Secondary outcomes

6.2.1 Nutrition knowledge

A set of interview questions on nutrition knowledge was developed based on the nutrition messages that Esoko sent to farmers as part of the VFC service. At baseline, all farmers were asked the same 16 questions regardless of their region or main crop. At endline, however, the nutrition knowledge questions consisted of 12 universal questions asked of everyone (six of which were from the baseline survey, with slight modifications) and crop-specific questions administered

only to those profiled (or would have been profiled) to the specific crop.[27] In total, there was three questions for those who had chosen cassava, maize, or groundnuts, and one question for those who had chosen millet as the crop for which they would like to receive advice. Given that less than half of the respondents chose one of the four crops for which we have crop-specific questions, all subsequent analysis is based on 11 of the 12 universal questions. One universal question was dropped from the analysis because it was not part of the repository of nutrition messages created for VFC, while all other questions were part of that repository. The same questions were asked separately and privately of the primary male and primary female of each household.

The main summary indicator for nutrition knowledge is the percentage of correct answers for the primary male and the primary female. We also combine the scores of the primary male and primary female using the Anderson Index to obtain a measure of household-level knowledge, as opposed to female's and male's individual knowledge. Specifically, following Anderson (2008), we demean both scores using the female and male sample average scores, respectively, and then scale the demeaned values by the standard deviation of the relevant score in the comparison group. We then calculate the weighted average of the two normalised scores, using the inverse of the covariance matrix for the normalised scores to generate the weights for each score. Relative to taking a simple average of the normalised scores, this method has the advantage of placing more weight on the score with the most independent variation. For the household-level indicator, we use only households with non-missing scores for both the primary male and primary female. A similar approach is followed to generate a household-level farming knowledge measure.

Table 6.5 reveals the mean value for the comparison group and the ITT estimates of being offered the VFC service on nutrition knowledge. On average, primary males have a higher percentage of correct answers than primary females (67.2% versus 65.5%). Being offered VFC has no impact on the primary male or primary female's nutrition knowledge or their combined score, and these results are similar across the two models with basic controls and extended controls. Table 10.3 and Table 10.4 in Annex D reveal the results for the individual items that make up the summary indicator.

Table 6.5: ITT estimates of VFC on female's and male's nutrition knowledge (summary measures)

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Percentage of correct answers (female)	65.512	-0.895	-0.941	3572
		(1.158)	(1.124)	
Percentage of correct answers (male)	67.232	-0.336	-0.214	2945
		(1.096)	(1.057)	
Anderson Index: nutrition combined correct percentages of females and males	0.011	-0.027	-0.026	2731
		(0.057)	(0.055)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – for household-level outcomes, these are household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone. For individual-level outcomes, the covariates are household size, whether household head is female, age of individual

[27] Households in the encouraged group were asked to select this crop/commodity during the profiling phase of the baseline survey. Households in the comparison group were asked to select the crop/commodity as part of the endline survey.

responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone. In addition, the model controls for the order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

6.2.2 Farming knowledge

As with the nutrition questions, the set of questions on farming knowledge was developed based on the list of agricultural messages that Vodafone sent to farmers as part of the VFC service. At baseline, all farmers were administered the same 12 questions independently of the primary crop they had identified in order to capture a range of common crops (Billings *et al*., 2018). At endline, five of these baseline questions were still included – although only one had answer choices that were identical to those at baseline – and seven new questions were added. Contrary to the universal set of questions at baseline, at endline only six questions were asked of all of respondents: three general questions and three questions on maize (which is grown in both the Central and Upper West regions). After these general questions, farmers in the Central region were asked three questions on cassava and three on cocoa, while farmers in the Upper West region were asked three questions on groundnut and three on millet.

As with the nutrition knowledge indicators, we construct a summary measure of farming knowledge from the 12 administered questions using the percentage of correct answers given by the primary male and the primary female. We then combine the percentage of correct answers across the primary male and primary female using the Anderson Index.

Table 6.6 reveals that the primary female correctly answered 68.7% of the questions and the primary male 71.6%. There is no impact of being offered the VFC service on the primary female or primary male or the joint index. The tables that reveal the results for the individual questions that make up the index can be found in Annex D (Table 10.5 and Table 10.6).

Table 6.6: ITT estimates of VFC on female's and male's farming knowledge (summary measures)

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Percentage of correct answers (female)	68.722	-0.065	-0.051	3572
		(0.634)	(0.622)	
Percentage of correct answers (male)	71.642	0.631	0.660	2945
		(0.655)	(0.652)	
Anderson Index: farming combined correct percentages of females and males	-0.019	0.020	0.021	2731
		(0.037)	(0.036)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – for household-level outcomes, these are household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone. For individual-level outcomes, the covariates are household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone. In addition, the model controls for the order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

6.2.3 Market access and practices

At endline, a subset of primary males and females responded to the market access module. Those that did not respond were those who did not actively sell their crops on the market as defined by not having sales revenue in the 2018 major season. For those that had sales revenue in the 2018 major season, we collected information with respect to the main crop (in terms of revenue) for distance to market, highest and lowest price at which crop was sold, number of buyers, and reason for selling to main buyer. For the lowest and highest price, we estimate the impacts for each of the three main crops – maize, cocoa, and groundnut – consistent with the tables above.[28]

Table 6.7 reveals that approximately 52.7% of primary females in the comparison group had sales revenue in the 2018 major season. For those with revenue, 81.6% responded that it took them 30 minutes or less to get to the place of sale, while 71% responded that they know more than one buyer. Approximately half of the primary females in the comparison group sell to the main buyer because of an immediate payment, and 20.3% would have obtained a better price if they had sold to a different buyer. In terms of impact, the VFC offer significantly increased the lowest and highest price received for maize but had no impact on any other indicator.

Table 6.7: ITT estimates of VFC on female's market access and practices

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Had sales revenue in the 2018 major season	0.527	-0.036	-0.039	3572
		(0.025)	(0.025)	
Takes 30 minutes or less to get to the market where main crop is sold	0.816	0.016	0.017	1827
		(0.022)	(0.022)	
Lowest price per kilogram received for maize from the 2018 major harvest	1.403	0.128	0.188*	314
		(0.092)	(0.101)	
Highest price per kilogram received for maize from the 2018 major harvest	1.610	0.215*	0.321***	312
		(0.121)	(0.122)	
Lowest price per kilogram received for cocoa from the 2018 major harvest	53.280	8.950	6.751	660
		(15.410)	(15.460)	
Highest price per kilogram received for cocoa from the 2018 major harvest	58.118	8.300	5.569	660
		(17.090)	(17.136)	
Lowest price per kilogram received for groundnut from the 2018 major harvest	1.827	-0.117	-0.130	242
		(0.119)	(0.124)	
Highest price per kilogram received for groundnut from the 2018 major harvest	2.046	-0.051	-0.099	241
		(0.147)	(0.151)	
Knows more than one buyer who would have been willing to buy their crop	0.710	0.019	0.015	1612
		(0.030)	(0.030)	
Reason respondent decided to sell to the main buyer: Best price	0.204	0.028	0.025	1734
		(0.023)	(0.022)	
Reason respondent decided to sell to the main buyer: Immediate payment	0.501	0.005	0.008	1734
		(0.032)	(0.032)	
	0.229	0.027	0.025	1569

[28] Prices per kilo are cleaned for outliers by replacing as missing values that are more than three standard deviations above or below the mean.

Better price if respondent had sold this crop at a different place		(0.034)	(0.034)	
Better price if respondent had sold this crop to a different buyer	0.203	0.021	0.020	1552
		(0.033)	(0.033)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 6.8 reveals the mean value for the comparison group and the ITT estimates of being offered the VFC service on the market access and practices of the primary male. It shows that 61% of primary males had sales revenue for the 2018 major season. In general, the descriptive statistics of market access for those with sales revenue are similar to those of the primary female: 84.7% responded that it took them 30 minutes or less to get to the place of sale, while 70.6% responded that they know more than one buyer. Approximately 43% of primary males in the comparison group sell to the main buyer because of an immediate payment, and 21.4% would have obtained a better price if they had sold to a different buyer. Unlike for the primary female, there is no impact of being offered the VFC service on prices or other indicators.

Table 6.8: ITT estimates of VFC on male's market access and practices

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Had sales revenue in the 2018 major season	0.610	-0.021	-0.025	2945
		(0.026)	(0.026)	
Takes 30 minutes or less to get to the market where main crop is sold	0.847	-0.008	-0.008	1758
		(0.021)	(0.021)	
Lowest price per kilogram received for maize from the 2018 major harvest	1.336	-0.069	-0.062	324
		(0.085)	(0.092)	
Highest price per kilogram received for maize from the 2018 major harvest	1.590	0.107	0.105	325
		(0.168)	(0.176)	
Lowest price per kilogram received for cocoa from the 2018 major harvest	56.647	11.872	11.082	677
		(16.411)	(16.405)	
Highest price per kilogram received for cocoa from the 2018 major harvest	60.886	5.262	4.122	677
		(16.121)	(16.028)	
Lowest price per kilogram received for groundnut from the 2018 major harvest	1.704	-0.117	-0.126	289
		(0.111)	(0.112)	
Highest price per kilogram received for groundnut from the 2018 major harvest	2.191	-0.085	-0.008	290
		(0.406)	(0.444)	
Knows more than one buyer who would have been willing to buy their crop	0.706	0.015	0.009	1611
		(0.033)	(0.033)	
Reason respondent decided to sell to the main buyer: Best price	0.228	0.010	0.013	1758
		(0.023)	(0.023)	
Reason respondent decided to sell to the main buyer: Immediate payment	0.433	0.029	0.030	1758
		(0.028)	(0.028)	

Better price if respondent had sold this crop at a different place	0.248	0.007	0.008	1558
		(0.027)	(0.028)	
Better price if respondent had sold this crop to a different buyer	0.214	0.006	0.005	1541
		(0.027)	(0.027)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

6.3 Summary

We find no evidence to suggest that access to the VFC service had any impact on dietary diversity for either the household or women, or on agriculture production and income. Point estimates in most cases result in precisely estimated zeros. The exceptions are marginally significant increases in the probability that a household consumes dairy and marginally significant reductions in the area of cocoa cultivated for households that produce cocoa. However, these marginally significant results could have occurred by chance given that we conducted 80 hypothesis tests, and thus we caution any reader against interpreting these results as indicating positive impacts.[29] Consistent with the null results on primary outcomes, we find no evidence that access to the VFC service led to improvements in secondary outcomes related to nutrition, farming knowledge, or market access of the primary male or primary female, the exception being a significant increase in the price received for maize for the primary female. Together these results suggest that providing access to the VFC service is not sufficient to lead to changes in the primary or secondary outcomes of interest.

[29] For example, interpreting characteristics based on the convention that a p-value below 0.05 is significant, we should expect to observe a significant difference for 1 out of every 20 tests simply by chance.

7 LATE impact estimates

In addition to the ITT estimate, we estimate the LATE of the VFC service for households that were induced to register and use the service by the randomly assigned offer (known as 'compliers'). As detailed in Section 3, we use 2SLS to estimate LATE, and in particular use the random variation in encouragement as an instrument for registering for and using the service in the previous 18 months preceding the endline survey. Approximately 68% of encouraged households (or 1,297 households) who were provided with the free offer of the VFC service registered for the VFC service and of these 50% (or 646 households) had used the service in the previous 18 months (see Section 5.1). Under the two assumptions discussed in Section 3.2.2, 2SLS estimates identify the causal impact of having received the VFC content for complier households.

7.1 First stage

To begin, we show the first-stage relationship of the 2SLS equation; that is, the relationship between the random offer of the VFC service to encouraged households and the self-reported measure of whether households used the VFC service during the study period, with usage being defined as using the VFC service in the previous 18 months to either make or receive calls, send or receive SMS, receive agriculture or nutrition information, receive weather or market price information, or call the helpline. The first-stage estimates are the regression-based analogues to the differences in usage between encouraged and comparison households. We assess the strength of the relationship between the excluded instrument and the endogenous indicator of usage, generalising the standard F-statistic to a context with clustered standard errors and potentially weak instruments using the Kleinbergen-Paap Wald F-Statistic. This statistic assesses whether the instrument is sufficiently predictive to enable inference about the parameter of interest.

Table 7.1 provides the first-stage estimates for the main variables from each set of indicators and reveals a very strong first stage. In all cases, the Kleinbergen-Paap F-Statistic exceeds the Staiger and Stock (1997) rule-of-thumb of 10 for rejecting instruments that are weak. We are therefore not concerned about bias from a weak first stage affecting our inference about the LATE parameters of interest.

Table 7.1: First-stage estimates from 2SLS regressions

	N	First-stage estimate	Kleibergen-Paap Wald rank F-statistic
First stage: Women's Dietary Diversity Score	3,706	0.340***	352.02
		(0.018)	
First stage: HDDS first stage	3,553	0.336***	326.70
		(0.019)	
First stage: Number of crops cultivated	3,737	0.341***	371.14
		(0.018)	
First stage: Total area cultivated	3,622	0.350***	383.00
		(0.018)	
First stage: Total cost of production	3,593	0.349***	386.68
		(0.018)	
First stage: Total profit from crops	3,562	0.350***	380.65

		(0.018)	
First stage: Female nutrition knowledge	3,572	0.338***	334.30
		(0.018)	
First stage: Male nutrition knowledge	2,945	0.365***	377.86
		(0.019)	
First stage: Female farming knowledge	3,572	0.338***	328.63
		(0.019)	
First stage: Male farming knowledge	2,945	0.365***	371.72
		(0.019)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the first-stage estimates from the instrumental variable regression, where being randomly offered the VFC service is used as an excluded instrument for the indicator variable for household-level use of the VFC service in the previous 18 months, controlling for region and the respective outcome at baseline.

Source: Authors' own

7.2 Primary outcomes

7.2.1 Household dietary diversity

Table 7.2 reveals the LATE estimates on household dietary diversity. The point estimates are simply the ratio of the ITT point estimate over the first-stage coefficient presented in Table 7.1, implying that they are about three times the size of the ITT treatment effects. As with the ITT estimates in Section 6.1, we find no impact of the VFC service on households that were induced to use the service as a result of the randomised encouragement. As expected, the LATE estimates are larger in magnitude than the ITT estimates in Table 6.1, but none – except the indicator for consuming dairy – are significant.

Table 7.2: LATE of VFC on household dietary diversity

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
HDDS (1–12)	5.878	0.204	0.154	3706
		(0.279)	(0.274)	
Household consumed cereals	0.901	0.035	0.032	3796
		(0.038)	(0.037)	
Household consumed roots and tubers	0.534	0.067	0.063	3778
		(0.050)	(0.050)	
Household consumed vegetables	0.665	0.042	0.035	3795
		(0.063)	(0.064)	
Household consumed fruit	0.667	-0.054	-0.063	3789
		(0.077)	(0.077)	
Household consumed meat/organ meat	0.209	0.067	0.063	3779
		(0.050)	(0.049)	
Household consumed eggs	0.107	0.026	0.023	3782
		(0.031)	(0.031)	
Household consumed seafood	0.855	-0.044	-0.044	3793

		(0.054)	(0.054)	
Household consumed legumes, pulses, nuts, and seeds	0.305	0.000	-0.009	3792
		(0.064)	(0.064)	
Household consumed dairy	0.130	0.069	0.070*	3796
		(0.043)	(0.042)	
Household consumed oils and fats	0.413	-0.031	-0.033	3758
		(0.065)	(0.065)	
Household consumed sweets	0.178	0.022	0.012	3749
		(0.051)	(0.050)	
Household consumed condiments	0.919	0.032	0.028	3781
		(0.033)	(0.032)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the second-stage estimates from the instrumental variable regression, where the endogenous variable – whether respondent reported using the VFC service over the preceding 18 months – is instrumented by the treatment indicator, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

7.2.2 Women's dietary diversity

Table 7.3 presents the LATE estimates of using the VFC service on women's dietary diversity. As with the ITT estimates, we find no impact of the VFC service on any of the indicators listed.

Table 7.3: LATE of VFC on women's dietary diversity

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
Women's Dietary Diversity Score (1–10)	4.338	-0.135	-0.160	3553
		(0.255)	(0.250)	
Met MDD-W	0.500	-0.053	-0.061	3553
		(0.081)	(0.080)	
Primary female consumed tubers and grains	0.983	-0.024	-0.026	3572
		(0.019)	(0.019)	
Primary female consumed pulses	0.188	-0.034	-0.036	3567
		(0.048)	(0.048)	
Primary female consumed dairy	0.100	0.023	0.027	3572
		(0.039)	(0.037)	
Primary female consumed meat/fish/poultry	0.883	-0.039	-0.036	3572
		(0.045)	(0.045)	
Primary female consumed eggs	0.085	-0.001	-0.002	3567
		(0.032)	(0.032)	
Primary female consumed green leafy vegetables	0.623	-0.030	-0.032	3569
		(0.070)	(0.070)	
Primary female consumed vitamin A-rich fruits and vegetables	0.139	0.039	0.031	3571
		(0.046)	(0.046)	

Primary female consumed other vegetables	0.616	-0.046	-0.054	3571
		(0.078)	(0.076)	
Primary female consumed other fruits	0.616	-0.046	-0.054	3571
		(0.078)	(0.076)	
Primary female consumed nuts and seeds	0.101	0.038	0.031	3566
		(0.040)	(0.040)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the second-stage estimates from the instrumental variable regression, where the endogenous variable – whether respondent reported using the VFC service over the preceding 18 months – is instrumented by the treatment indicator, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

7.2.3 Agricultural production and income

Table 7.4 and Table 7.5 reveal the LATE estimates on agriculture outcomes. As with the ITT, we find no impacts of the VFC service on households that were induced to use the service as a result of the randomised encouragement. As expected, the LATE estimates are larger in magnitude than the ITT estimates in Table 6.3 and Table 6.4, but none except the indicators for the area cultivated for cocoa are significant. The LATE estimates suggest that complier households that grow cocoa reduced the area of cocoa cultivated by 24%.

Table 7.4: LATE of VFC on crop cultivation

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
Number of crops cultivated	2.774	0.213	0.168	3737
		(0.230)	(0.225)	
Total area cultivated (acres) (log)	1.718	-0.040	-0.069	3622
		(0.112)	(0.110)	
Household grows maize	0.724	0.072	0.066	3737
		(0.054)	(0.054)	
Area of maize cultivated (acres) (log)	0.989	0.025	0.008	2765
		(0.083)	(0.082)	
Yield of maize (kg/acre) (log)	5.314	0.052	0.026	2734
		(0.193)	(0.192)	
Household grows cocoa	0.296	-0.057	-0.062	3737
		(0.060)	(0.060)	
Area of cocoa cultivated (acres) (log)	1.586	-0.223	-0.241*	1046
		(0.145)	(0.142)	
Yield of cocoa (kg/acre) (log)	3.209	-0.058	-0.047	1035
		(0.468)	(0.462)	
Household grows groundnut	0.311	0.042	0.042	3737
		(0.052)	(0.052)	
Area of groundnut cultivated (acres) (log)	1.051	-0.014	-0.051	1191

		(0.078)	(0.078)	
Yield of groundnut (kg/acre) (log)	5.021	-0.216	-0.189	1169
		(0.206)	(0.196)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the second-stage estimates from the instrumental variable regression, where the endogenous variable – whether respondent reported using VFC service over the preceding 18 months – is instrumented by the treatment indicator, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone – and order of survey modules. Variables for yield are screened for outliers before taking the log value: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 7.5: LATE of VFC on value, cost, and profit of crop production (GHS)

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
Total value of production (IHS)	7.544	-0.187	-0.278	3591
		(0.340)	(0.333)	
Total input costs (IHS)	6.616	0.107	0.067	3593
		(0.280)	(0.275)	
Total profit (IHS)	3.384	-0.019	-0.290	3562
		(0.979)	(0.954)	
Total value of maize produced (IHS)	6.603	0.049	0.002	2731
		(0.223)	(0.225)	
Input cost of maize (IHS)	5.714	0.022	0.029	2736
		(0.319)	(0.315)	
Profit from maize (IHS)	2.257	0.052	-0.143	2714
		(0.879)	(0.873)	
Total value of cocoa produced (IHS)	6.871	-0.484	-0.491	1034
		(0.895)	(0.892)	
Input cost of cocoa (IHS)	5.953	-0.268	-0.207	1038
		(0.516)	(0.513)	
Profit from cocoa (IHS)	3.949	0.604	0.530	1025
		(1.456)	(1.421)	
Total value of groundnut produced (IHS)	6.668	-0.215	-0.207	1181
		(0.278)	(0.269)	
Input cost of groundnut (IHS)	5.215	-0.057	-0.076	1180
		(0.613)	(0.612)	
Profit from groundnut (IHS)	2.896	-1.623	-1.647	1170
		(1.178)	(1.133)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the second-stage estimates from the instrumental variable regression, where the endogenous variable – whether respondent reported using VFC service over the preceding 18 months – is instrumented by the treatment indicator, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone – and order of survey modules. Variables of value of production and cost of production are screened for outliers before using the IHS transformation: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

7.3 Secondary outcomes

7.3.1 Nutrition knowledge

Table 7.6 presents the LATE estimates of registering for and using the VFC service on the nutrition knowledge of the primary male and primary female. As with the ITT estimates, there are no impacts on nutrition knowledge.

Table 7.6: LATE of VFC on female's and male's nutrition knowledge (summary measures)

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
Percentage of correct answers (female)	65.512	-2.653	-2.926	3572
		(3.418)	(3.396)	
Percentage of correct answers (male)	67.232	-0.920	-0.782	2945
		(2.990)	(2.884)	
Anderson Index: nutrition combined correct percentages of females and males	0.011	-0.075	-0.072	2731
		(0.154)	(0.150)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the second-stage estimates from the instrumental variable regression, where the endogenous variable – whether respondent reported using VFC service over the preceding 18 months – is instrumented by the treatment indicator, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – for household-level outcomes, these are household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone. For individual-level outcomes, the covariates are household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone. The model also controls for the order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

7.3.2 Farming knowledge

Table 7.7 presents the LATE estimates of registering for and using the VFC service on the farming knowledge of the primary male and primary female. As with the ITT estimates, there are no impacts on farming knowledge.

Table 7.7: LATE of VFC on female's and male's farming knowledge (summary measures)

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
Percentage of correct answers (female)	68.722	-0.194	-0.240	3572
		(1.874)	(1.873)	
Percentage of correct answers (male)	71.642	1.725	1.859	2945
		(1.776)	(1.777)	
Anderson Index: farming combined correct percentages of females and males	-0.019	0.054	0.060	2731
		(0.099)	(0.099)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the second-stage estimates from the instrumental variable regression, where the endogenous variable – whether respondent reported using VFC service over the preceding 18 months – is instrumented by the treatment indicator, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – for household-level outcomes, these are household size, whether household head is female, whether household head is literate, PPI score, and whether household owns a mobile phone. For individual-level outcomes, the covariates are household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone. The model also controls for the order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

7.3.3 Market access and practices

Table 7.8 and Table 7.9 present the LATE estimates of registering for and using the VFC service on market access and practices of the primary male and primary female. As with the ITT estimates, there are no impacts on market access and practices of the primary male or primary female, with the exception of significantly higher prices of maize for the primary female.

Table 7.8: LATE of VFC on female's market access and practices

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
Had sales revenue in the 2018 major season	0.527	-0.106	-0.115	3572
		(0.075)	(0.074)	
Takes 30 minutes or less to get to the market where main crop is sold	0.816	0.045	0.047	1827
		(0.060)	(0.061)	
Lowest price per kilogram received for maize from the 2018 major harvest	1.403	0.379	0.561*	314
		(0.274)	(0.294)	
Highest price per kilogram received for maize from the 2018 major harvest	1.610	0.640*	0.956***	312
		(0.363)	(0.363)	
Lowest price per kilogram received for cocoa from the 2018 major harvest	53.280	22.676	17.104	660
		(39.088)	(38.885)	
Highest price per kilogram received for cocoa from the 2018 major harvest	58.118	21.053	14.120	660
		(43.341)	(43.041)	
Lowest price per kilogram received for groundnut from the 2018 major harvest	1.827	-0.292	-0.336	242
		(0.299)	(0.316)	
Highest price per kilogram received for groundnut from the 2018 major harvest	2.046	-0.128	-0.255	241
		(0.367)	(0.387)	
Knows more than one buyer who would have been willing to buy their crop	0.710	0.050	0.039	1612
		(0.079)	(0.078)	
Reason respondent decided to sell to the main buyer: Best price	0.204	0.077	0.069	1734
		(0.061)	(0.060)	
Reason respondent decided to sell to the main buyer: Immediate payment	0.501	0.014	0.022	1734
		(0.087)	(0.086)	
Better price if respondent had sold this crop at a different place	0.229	0.071	0.067	1569
		(0.091)	(0.092)	
Better price if respondent had sold this crop to a different buyer	0.203	0.056	0.054	1552
		(0.089)	(0.090)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 7.9: LATE of VFC on male's market access and practices

	Comparison mean	LATE estimates, basic controls	LATE estimates, extended controls	N
Had sales revenue in the 2018 major season	0.610	-0.059	-0.068	2945
		(0.072)	(0.072)	
Takes 30 minutes or less to get to the market where main crop is sold	0.847	-0.021	-0.020	1758
		(0.054)	(0.054)	
Lowest price per kilogram received for maize from the 2018 major harvest	1.336	-0.192	-0.173	324
		(0.235)	(0.249)	
Highest price per kilogram received for maize from the 2018 major harvest	1.590	0.309	0.301	325
		(0.479)	(0.489)	
Lowest price per kilogram received for cocoa from the 2018 major harvest	56.647	30.104	27.966	677
		(42.003)	(41.461)	
Highest price per kilogram received for cocoa from the 2018 major harvest	60.886	13.402	10.441	677
		(40.985)	(40.181)	
Lowest price per kilogram received for groundnut from the 2018 major harvest	1.704	-0.315	-0.330	289
		(0.300)	(0.293)	
Highest price per kilogram received for groundnut from the 2018 major harvest	2.191	-0.230	-0.021	290
		(1.082)	(1.141)	
Knows more than one buyer who would have been willing to buy their crop	0.706	0.038	0.024	1611
		(0.086)	(0.085)	
Reason respondent decided to sell to the main buyer: Best price	0.228	0.027	0.034	1758
		(0.060)	(0.061)	
Reason respondent decided to sell to the main buyer: Immediate payment	0.433	0.075	0.079	1758
		(0.075)	(0.074)	
Better price if respondent had sold this crop at a different place	0.248	0.019	0.022	1558
		(0.071)	(0.071)	
Better price if respondent had sold this crop to a different buyer	0.214	0.015	0.014	1541
		(0.070)	(0.070)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

7.4 Summary

As with the ITT results, we find no evidence to suggest that registering for and using the VFC service had any impact on dietary diversity for either the household in general or women in particular, or on agricultural production and income. Point estimates, while three times larger than the ITT estimates, are not significant. The exceptions are marginally significant increases in the probability that a household consumes dairy and marginally significant reductions in the area of cocoa cultivated for farmers that produce cocoa, which likely occurred by chance given the multiple tests that were conducted. Consistent with the null results on primary outcomes, we find no evidence that registering for and using the VFC service led to improvements in secondary outcomes related to nutrition, farming knowledge, or market access and practices of the primary male or primary female, with the only exception being the higher price received by the primary female for maize. Together these results suggest that the VFC service did not lead to changes in the primary or secondary outcomes of interest even for compliers.

8 Sub-randomisation and heterogeneity

Although Sections 6 and 7 revealed that there are no impacts of being offered the VFC service or being exposed to the service for the study population on average, there may nonetheless be impacts on specific subgroups. In this section, we take advantage of the evaluation design and analyse impacts across different subgroups that we believe *a priori* may interact differently with the VFC service.

First, we use the randomly assigned variation in whether the primary female or the primary male was offered access to the VFC service to explore whether targeting leads to a differential impact of the service on the primary or secondary outcomes. As revealed in the baseline report, females have less access to mobile phones and have different sources of information to men (Billings *et al*., 2018). Moreover, Section 5 reveals that there are differences across gender in how individuals interact with the service, and these may lead to larger impacts in one group relative to the other.

Second, we explore heterogeneity in impacts across region. The baseline report reveals large differences across regions in demographics, agriculture production, and mobile phone service and access (Billings *et al*., 2018). These differences likely lead to differences in how households interact with the VFC service, as seen in Section 5. We take advantage of the stratification that randomised EAs to encouraged and comparison groups within each region and assume that within each region these two groups were similar at baseline. Thus, the comparison of encouraged and comparison households at endline within each region provides unbiased impact estimates.

Lastly, we explore whether there is any heterogeneity in impacts by baseline household wealth. To do so, we use the PPI, which maps each household to the likelihood that they fall below 150% of the NPL in Ghana.[30] In our sample, these likelihoods range from 0 to 100, with a mean likelihood of 53.7% and a median likelihood of 58.1%. *A priori*, we do not know if households that are poorer will interact more or less with the VFC service. On the one hand, they may have less access to information and lower baseline knowledge, meaning they may find the information provided by the VFC service more useful and there may be more room for improvement. On the other hand, they may not have the necessary resources to act upon the information being provided, thereby leading to smaller impacts.

For the sub-randomisation and heterogeneity analysis, we estimate ITT impacts on the primary and secondary outcomes and their respective components.

8.1 Sub-randomisation of male and female targeting

We focus the analysis on dual-headed households that were eligible for the primary male and primary female sub-randomisation and estimate the ITT impacts for the primary male and primary female, as detailed in Section 3.2.1. The first column in the tables presents the mean value in the endline survey for all dual-headed households in the comparison group that would have been eligible for the household-level randomisation. The second and third columns display the ITT impact estimate for households that were randomly assigned to target the primary female or randomly assigned to target the primary male, relative to being from a household eligible for the household-level randomisation but from a comparison EA. The fourth column shows the p-value from an F-test of the null hypothesis that there is no difference in impact between targeting the primary male or the primary female. All estimates and p-values are based on standard errors that

[30] The PPI uses a country- and year-specific set of 10 questions to calculate the likelihood that a household is living below different national and international poverty lines. See Billings *et al*. (2018) for more detail.

are clustered at the EA level and control for only the level of stratification and the baseline value of the outcome variable.

8.1.1 Primary outcomes

Table 8.1 reveals that although targeting the VFC service to the primary male or primary female did not lead to impacts on the overall HDDS, there are improvements for a few individual food groups when the primary female is targeted. Targeting the VFC service to the primary female leads to increases in the probability that the household consumes roots and tubers (marginally significant), and dairy (significant at the 1% level). Although the size of the coefficients and significance levels vary across the female and male targeting, with the exception of consuming sweets and condiments, we cannot reject the null hypothesis that the impacts are the same across the targeting.

Table 8.1: Heterogeneity of VFC's impacts on household dietary diversity, by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
HDDS (1–12)	5.900	0.123	0.042	0.331	3,213
		(0.110)	(0.105)		
Household consumed cereals	0.905	0.005	0.020	0.272	3,288
		(0.016)	(0.014)		
Household consumed roots and tubers	0.519	0.036*	0.012	0.174	3,273
		(0.021)	(0.019)		
Household consumed vegetables	0.668	0.012	0.035	0.343	3,288
		(0.024)	(0.026)		
Household consumed fruit	0.667	-0.009	-0.041	0.120	3,282
		(0.029)	(0.029)		
Household consumed meat/organ meat	0.215	0.034	0.032	0.899	3,273
		(0.021)	(0.021)		
Household consumed eggs	0.107	0.005	0.007	0.917	3,277
		(0.014)	(0.013)		
Household consumed seafood	0.852	-0.018	-0.020	0.888	3,288
		(0.021)	(0.021)		
Household consumed legumes, pulses, nuts, and seeds	0.312	0.020	-0.016	0.111	3,286
		(0.025)	(0.024)		
Household consumed dairy	0.126	0.046***	0.019	0.113	3,290
		(0.017)	(0.018)		
Household consumed oils and fats	0.426	-0.016	-0.003	0.593	3,255
		(0.025)	(0.027)		
Household consumed sweets	0.185	0.020	-0.015	0.072*	3,249
		(0.021)	(0.019)		
Household consumed condiments	0.923	-0.003	0.014	0.089*	3,275
		(0.013)	(0.012)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.2 presents the ITT estimates of offering the VFC service to either the primary female or primary male on the primary female's dietary diversity. Although targeting the primary male or primary female does not lead to impacts on the overall HDDS or the probability that she met the minimum standard, targeting the female significantly increases the probability that she consumes dairy by 3 percentage points and marginally decreases the probability that she consumes tubers and grain (although the size of the decrease is small in magnitude relative to the mean). The same is not true for targeting men: there are no impacts on any food group when the primary male is targeted. Differences across the primary male and primary female are significant for the consumption of dairy and marginally significant for the consumption of vitamin A-rich fruits and vegetables. This suggests that targeting does matter as a woman's diet improved only when she was targeted to receive the VFC messages. It also suggests that information may not be shared across individuals.

Table 8.2: Heterogeneity of VFC's impacts on women's dietary diversity, by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
Women's Dietary Diversity Score (1–10)	4.327	0.044	-0.082	0.155	3,051
		(0.099)	(0.100)		
Met MDD-W	0.495	0.004	-0.027	0.261	3,051
		(0.029)	(0.033)		
Primary female consumed tubers and grains	0.984	-0.015*	-0.005	0.180	3,068
		(0.008)	(0.008)		
Primary female consumed pulses	0.189	0.001	-0.016	0.355	3,064
		(0.019)	(0.019)		
Primary female consumed dairy	0.093	0.032**	-0.001	0.034**	3,068
		(0.016)	(0.015)		
Primary female consumed meat/fish/poultry	0.877	-0.009	-0.011	0.891	3,068
		(0.018)	(0.019)		
Primary female consumed eggs	0.085	0.001	-0.001	0.869	3,064
		(0.014)	(0.013)		
Primary female consumed green leafy vegetables	0.623	-0.008	0.017	0.305	3,065
		(0.025)	(0.027)		
Primary female consumed vitamin A-rich fruits and vegetables	0.145	0.030	-0.004	0.061*	3,067
		(0.019)	(0.019)		
Primary female consumed other vegetables	0.611	-0.003	-0.032	0.198	3,067
		(0.030)	(0.031)		
Primary female consumed other fruits	0.611	-0.003	-0.032	0.198	3,067
		(0.030)	(0.031)		
Primary female consumed nuts and seeds	0.105	0.019	0.008	0.579	3,063
		(0.016)	(0.018)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.3 and Table 8.4 present the ITT impacts of targeting the VFC service to the primary female or primary male on agriculture outcomes. As with the impacts found in Section 6, targeting the primary male and primary female has no impact on crop diversity, area cultivated, crops grown, yields, value of production, input costs, or profits, with the exception of a marginally significant decrease in the profit of groundnut when the VFC service is targeted to men. Differences in impact across the targeted female and male are significant only with respect to input costs, where targeting the primary male leads to marginally significant higher input costs compared to targeting the primary female.

Table 8.3: Heterogeneity of VFC's impacts on crop cultivation, by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
Number of crops cultivated	2.820	0.116	0.109	0.905	3,249
		(0.087)	(0.088)		
Total area cultivated (acres) (log)	1.772	-0.015	0.002	0.576	3,176
		(0.043)	(0.042)		
Household grows maize	0.736	0.034	0.030	0.863	3,249
		(0.022)	(0.023)		
Area of maize cultivated (acres) (log)	1.026	0.008	0.008	0.992	2,460
		(0.033)	(0.033)		
Yield of maize (kg/acre) (log)	5.346	0.025	0.056	0.663	2,431
		(0.081)	(0.079)		
Household grows cocoa	0.287	-0.013	-0.014	0.909	3,249
		(0.020)	(0.021)		
Area of cocoa cultivated (acres) (log)	1.651	-0.086	-0.091	0.924	889
		(0.060)	(0.066)		
Yield of cocoa (kg/acre) (log)	3.254	-0.018	-0.030	0.940	879
		(0.186)	(0.198)		
Household grows groundnut	0.330	0.013	0.019	0.730	3,249
		(0.021)	(0.021)		
Area of groundnut cultivated (acres) (log)	1.066	0.018	-0.027	0.208	1,105
		(0.036)	(0.035)		
Yield of groundnut (kg/acre) (log)	5.014	-0.074	-0.038	0.660	1,083
		(0.082)	(0.092)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. Variables of yield are screened for outliers before taking the log value: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.4: Heterogeneity of VFC's impacts on value of production, costs, and profits (GHS), by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
Total value of production (IHS)	7.672	-0.032	-0.040	0.935	3,145
		(0.120)	(0.124)		
Total input costs (IHS)	6.661	-0.001	0.180	0.053*	3,146
		(0.109)	(0.113)		
Total profit (IHS)	3.628	0.238	-0.296	0.100*	3,116
		(0.384)	(0.397)		
Total value of maize produced (IHS)	6.699	0.022	0.041	0.817	2,425
		(0.090)	(0.094)		
Input cost of maize (IHS)	5.774	-0.108	0.098	0.076*	2,430
		(0.134)	(0.136)		
Profit from maize (IHS)	2.347	0.133	0.186	0.863	2,408
		(0.396)	(0.350)		
Total value of cocoa produced (IHS)	7.004	-0.157	-0.196	0.913	876
		(0.380)	(0.393)		
Input cost of cocoa (IHS)	6.005	-0.175	-0.056	0.637	880
		(0.233)	(0.251)		
Profit from cocoa (IHS)	4.283	-0.104	0.387	0.386	867
		(0.591)	(0.671)		
Total value of groundnut produced (IHS)	6.671	-0.017	-0.113	0.372	1,095
		(0.113)	(0.126)		
Input cost of groundnut (IHS)	5.173	0.012	0.158	0.511	1,095
		(0.246)	(0.284)		
Profit from groundnut (IHS)	2.899	-0.409	-0.924*	0.285	1,085
		(0.497)	(0.535)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. Variables of value of production and cost of production are screened for outliers before taking the IHS transformation: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

8.1.2 Secondary outcomes

Table 8.5 and Table 8.6 present the ITT impact estimates for offering the VFC service to the primary female or primary male on nutrition and farming knowledge, respectively. As with the overall impacts presented in Section 6, targeting the primary female or primary male has no impact on either the primary female or primary male's nutrition or farming knowledge.

Table 8.5: Heterogeneity of VFC's impacts on nutrition knowledge (summary), by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
Percentage of correct answers (female)	66.418	-1.485	-0.639	0.303	3,068
		(1.247)	(1.259)		
Percentage of correct answers (male)	67.232	-0.810	0.118	0.250	2,942
		(1.181)	(1.155)		
Anderson Index: nutrition combined correct percentages of females and males	0.011	-0.062	0.007	0.068*	2,728
		(0.060)	(0.060)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.6: Heterogeneity of VFC's impacts on farming knowledge (summary), by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
Percentage of correct answers (female)	69.531	0.143	-0.180	0.585	3,068
		(0.673)	(0.737)		
Percentage of correct answers (male)	71.642	0.707	0.525	0.782	2,942
		(0.713)	(0.750)		
Anderson Index: nutrition combined correct percentages of females and males	-0.019	0.026	0.012	0.690	2,728
		(0.038)	(0.042)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.7 reveals that the impact of the VFC offer on the maize price received for the primary female is significant when targeted to the primary male, although differences in impact are not statistically different across targeting. When targeted to the primary male, there is also a marginally

significant increase in the percentage of primary females that report that the reason for selling to the main buyer is because of a better price. In general, Table 8.7 reveals that targeting does not matter for impacts on women's market access or practices, as primary females still receive higher prices when the service is offered to the primary male, thus suggesting that the information is being shared within the household.

Table 8.8 reveals that there are no impacts of targeting either the primary female or primary male on the primary male's market access or practices, with the exception of a negative impact on the lowest price for groundnut when targeted to the primary male.

Table 8.7: Heterogeneity of VFC's impacts on female's market access and practices, by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
Had sales revenue in the 2018 major season	0.517	-0.024	-0.035	0.597	3,068
		(0.026)	(0.028)		
Takes 30 minutes or less to get to the market where main crop is sold	0.810	0.015	0.021	0.797	1,548
		(0.026)	(0.028)		
Lowest price per kilogram received for maize from the 2018 major harvest	1.382	0.104	0.207	0.506	266
		(0.098)	(0.147)		
Highest price per kilogram received for maize from the 2018 major harvest	1.578	0.183	0.346**	0.398	267
		(0.151)	(0.167)		
Lowest price per kilogram received for cocoa from the 2018 major harvest	55.896	8.062	10.081	0.917	545
		(19.629)	(20.330)		
Highest price per kilogram received for cocoa from the 2018 major harvest	59.770	10.278	6.726	0.863	545
		(21.943)	(21.165)		
Lowest price per kilogram received for groundnut from the 2018 major harvest	1.798	-0.108	-0.062	0.760	215
		(0.135)	(0.147)		
Highest price per kilogram received for groundnut from the 2018 major harvest	2.015	-0.101	0.094	0.319	215
		(0.165)	(0.189)		
Knows more than one buyer who would have been willing to buy their crop	0.720	0.004	0.029	0.477	1,364
		(0.034)	(0.036)		
Reason respondent decided to sell to the main buyer: Best price	0.209	0.027	0.050*	0.454	1,463
		(0.029)	(0.028)		
Reason respondent decided to sell to the main buyer: Immediate payment	0.500	0.012	-0.021	0.382	1,463
		(0.038)	(0.038)		
Better price if respondent had sold this crop at a different place	0.225	0.048	0.014	0.402	1,326
		(0.041)	(0.038)		
Better price if respondent had sold this crop to a different buyer	0.201	0.042	-0.006	0.189	1,310
		(0.038)	(0.036)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.8: Heterogeneity of VFC's impacts on male's market access and practices, by mNutrition sub-randomisation arms

	Comparison mean	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH= M-HH	N
Had sales revenue in the 2018 major season	0.610	-0.027	-0.015	0.615	2,942
		(0.029)	(0.029)		
Takes 30 minutes or less to get to the market where main crop is sold	0.847	-0.014	-0.003	0.640	1,757
		(0.025)	(0.023)		
Lowest price per kilogram received for maize from the 2018 major harvest	1.336	-0.095	-0.047	0.631	323
		(0.094)	(0.103)		
Highest price per kilogram received for maize from the 2018 major harvest	1.590	0.112	0.105	0.979	324
		(0.244)	(0.172)		
Lowest price per kilogram received for cocoa from the 2018 major harvest	56.647	6.087	17.129	0.540	677
		(17.574)	(19.671)		
Highest price per kilogram received for cocoa from the 2018 major harvest	60.886	0.734	9.441	0.607	677
		(17.970)	(18.381)		
Lowest price per kilogram received for groundnut from the 2018 major harvest	1.704	-0.012	-0.203*	0.205	289
		(0.162)	(0.102)		
Highest price per kilogram received for groundnut from the 2018 major harvest	2.191	-0.299	0.084	0.399	290
		(0.256)	(0.583)		
Knows more than one buyer who would have been willing to buy their crop	0.706	-0.018	0.045	0.069*	1,610
		(0.039)	(0.035)		
Reason respondent decided to sell to the main buyer: Best price	0.228	-0.005	0.024	0.290	1,757
		(0.027)	(0.027)		
Reason respondent decided to sell to the main buyer: Immediate payment	0.433	0.037	0.019	0.567	1,757
		(0.033)	(0.033)		
Better price if respondent had sold this crop at a different place	0.248	0.023	-0.007	0.363	1,558
		(0.032)	(0.032)		
Better price if respondent had sold this crop to a different buyer	0.214	0.027	-0.013	0.205	1,540
		(0.032)	(0.032)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are the impact estimates for dual-headed households of randomly targeting the primary female or primary male to receive the VFC offer. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

8.2 Heterogeneity of impact by region

To explore heterogeneity across regions we estimate the ITT model detailed in Section 3.2.1 separately for the Central and Upper West regions. The results are presented in tables where columns 1–3 reveal the mean for the comparison group, the impact estimate, and the number of observations for the Central region, while columns 4–6 reveal the same statistics for the Upper West region. The last column shows the p-value from an F-test of the null hypothesis that there is no difference in impact between the Upper West and Central regions. All estimates and p-values

are based on standard errors that are clustered at the EA level and control for only the baseline value of the outcome variable.

8.2.1 Primary outcomes

Table 8.9 reveals that the Central region has a higher HDDS than the Upper West region (6.3 points versus 5.4 points). Offering the VFC service in the Central region leads to a marginally significant increase in the HDDS, by 0.25 points. This represents a 4% increase relative to the comparison group's mean. There are also significant increases of approximately four percentage points in the probabilities that a household consumes cereals (marginally significant) and dairy (significant at the 5% level). In the Upper West region there are no impacts of the VFC offer, with the exception of marginally increasing the probability that a household consumes roots and tubers. Differences in impact across the Central and Upper West regions are large and significant for the overall HDDS, as well as for the probability that a household consumes cereals, fruits, seafood, and sweets.

As with household-level diets, women's dietary diversity score is higher in the Central region compared to the Upper West region, and a higher proportion of women in the Central region meet the minimum levels (59.4% versus 40.5%). Unlike with the HDDS, the VFC offer has no impact on women's dietary diversity in either the Central region or the Upper West region (Table 8.10). However, there are a few marginally significant differences in impact, with people in the Central region being more likely than those in the Upper West region to consume other fruits and vegetables.

Table 8.11 and Table 8.12 present the ITT estimates separately by region of being offered the VFC service on agricultural outcomes. There are no impacts on any agricultural outcomes in either the Central region or the Upper West region.

Table 8.9: Heterogeneity of VFC's impacts on HDDS, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
HDDS (1–12)	6.307	0.253*	1,877	5.427	-0.111	1,829	0.050*
		(0.136)			(0.127)		
Household consumed cereals	0.850	0.036*	1,915	0.954	-0.015	1,881	0.038**
		(0.021)			(0.014)		
Household consumed roots and tubers	0.861	0.002	1,916	0.192	0.046*	1,862	0.184
		(0.019)			(0.028)		
Household consumed vegetables	0.619	0.037	1,914	0.712	-0.009	1,881	0.287
		(0.033)			(0.028)		
Household consumed fruit	0.824	0.029	1,914	0.504	-0.064	1,875	0.068*
		(0.030)			(0.042)		
Household consumed meat/organ meat	0.151	0.014	1,914	0.270	0.032	1,865	0.602
		(0.018)			(0.030)		
Household consumed eggs	0.179	0.019	1,909	0.032	-0.002	1,873	0.308
		(0.019)			(0.009)		
Household consumed seafood	0.922	0.017	1,913	0.786	-0.046	1,880	0.083*
		(0.016)			(0.033)		
Household consumed legumes, pulses, nuts, and seeds	0.290	0.008	1,912	0.319	-0.008	1,880	0.699
		(0.032)			(0.029)		
Household consumed dairy	0.152	0.041**	1,912	0.108	0.006	1,884	0.215
		(0.019)			(0.021)		
Household consumed oils and fats	0.243	0.020	1,907	0.591	-0.043	1,851	0.145
		(0.031)			(0.030)		
Household consumed sweets	0.251	0.040	1,889	0.103	-0.025	1,860	0.056*
		(0.029)			(0.018)		
Household consumed condiments	0.966	0.012	1,916	0.870	0.010	1,865	0.907

		(0.011)			(0.019)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.10: Heterogeneity of VFC's impacts on women's dietary diversity, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Women's Dietary Diversity Score (1–10)	4.670	0.090	1,781	4.003	-0.181	1,772	0.114
		(0.123)			(0.120)		
Met MDD-W	0.594	0.017	1,781	0.405	-0.052	1,772	0.200
		(0.040)			(0.036)		
Primary female consumed tubers and grains	0.993	0.000	1,785	0.973	-0.016	1,787	0.216
		(0.004)			(0.013)		
Primary female consumed pulses	0.127	-0.009	1,783	0.249	-0.015	1,784	0.858
		(0.021)			(0.025)		
Primary female consumed dairy	0.096	0.019	1,785	0.105	-0.001	1,787	0.421
		(0.016)			(0.021)		
Primary female consumed meat/fish/poultry	0.937	0.007	1,785	0.828	-0.034	1,787	0.168
		(0.014)			(0.026)		
Primary female consumed eggs	0.139	-0.007	1,784	0.032	0.005	1,783	0.581
		(0.018)			(0.012)		
Primary female consumed green leafy vegetables	0.594	-0.004	1,784	0.652	-0.016	1,785	0.789
		(0.038)			(0.029)		
Primary female consumed vitamin A-rich fruits and vegetables	0.127	0.011	1,785	0.151	0.014	1,786	0.925
		(0.021)			(0.023)		
Primary female consumed other vegetables	0.770	0.030	1,784	0.461	-0.062	1,787	0.077*

		(0.033)			(0.041)		
Primary female consumed other fruits	0.770	0.030	1,784	0.461	-0.062	1,787	0.077*
		(0.033)			(0.041)		
Primary female consumed nuts and seeds	0.116	0.011	1,785	0.086	0.014	1,781	0.914
		(0.018)			(0.021)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.11: Heterogeneity of VFC's impacts on crop cultivation, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Number of crops cultivated	2.930	0.024	1,868	2.616	0.136	1,869	0.472
		(0.120)			(0.100)		
Total area cultivated (acres) (log)	1.769	-0.073	1,767	1.669	0.047	1,855	0.123
		(0.065)			(0.044)		
Household grows maize	0.641	0.044	1,868	0.808	0.001	1,869	0.236
		(0.027)			(0.024)		
Area of maize cultivated (acres) (log)	0.800	-0.023	1,238	1.141	0.031	1,527	0.302
		(0.028)			(0.044)		
Yield of maize (kg/acre) (log)	5.197	-0.017	1,213	5.407	0.016	1,521	0.804
		(0.105)			(0.079)		
Household grows cocoa	0.588	-0.040	1,868	-	-	-	-
		(0.041)					
Area of cocoa cultivated (acres) (log)	1.586	-0.083	1,046	-	-	-	-
		(0.054)					
Yield of cocoa (kg/acre) (log)	3.209	-0.023	1,035	-	-	-	-
		(0.180)					

Household grows groundnut	-	-	-	0.617	0.033	1,869	-
					(0.036)		
Area of groundnut cultivated (acres) (log)	-	-	-	1.051	-0.003	1,191	-
					(0.030)		
Yield of groundnut (kg/acre) (log)	-	-	-	5.021	-0.082	1,169	-
					(0.079)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. Variables of area, yield, value of production, and cost of production are screened for outliers: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.12: Heterogeneity of VFC's impacts on value, costs, and profits (GHS) of crop production, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Total value of production (IHS)	7.395	-0.210	1,736	7.685	0.052	1,855	0.277
		(0.219)			(0.103)		
Total input costs (IHS)	6.265	0.055	1,755	6.953	0.020	1,838	0.856
		(0.141)			(0.136)		
Total profit (IHS)	4.033	-0.351	1,724	2.769	0.310	1,838	0.335
		(0.496)			(0.476)		
Total value of maize produced (IHS)	6.140	-0.016	1,234	6.983	0.016	1,497	0.834
		(0.118)			(0.098)		
Input cost of maize (IHS)	4.721	0.100	1,238	6.528	-0.066	1,498	0.467
		(0.161)			(0.163)		
Profit from maize (IHS)	3.520	-0.078	1,233	1.211	0.055	1,481	0.823
		(0.337)			(0.496)		
Total value of cocoa produced (IHS)	6.871	-0.186	1,034	-	-	-	-
		(0.347)					

Input cost of cocoa (IHS)	5.953	-0.103	1,038	-	-	-	-
		(0.198)					
Profit from cocoa (IHS)	3.949	0.232	1,025	-	-	-	-
		(0.563)					
Total value of groundnut produced (IHS)				6.668	-0.082	1,181	-
	-	-	-		(0.104)		
Input cost of groundnut (IHS)				5.215	-0.022	1,180	-
	-	-	-		(0.233)		
Profit from groundnut (IHS)				2.896	-0.615	1,170	-
	-	-	-		(0.436)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. Variables of area, yield, value of production, and cost of production are screened for outliers: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

8.2.2 Secondary outcomes

Table 8.13 and Table 8.14 present the ITT impact estimates separately for the Central and Upper West regions of being offered the VFC service on nutrition and farming knowledge, respectively. There are no impacts on nutrition or farming knowledge for either the primary male or primary female in the Central or Upper West region.

Table 8.15 and Table 8.16 present the ITT impact estimates separately for the Central and Upper West regions of being offered the VFC service on the primary female and primary male's market access and practices, respectively. Of note is that in the Upper West region, there are much lower rates of having sales revenue for both the primary female (75.3% in the Central region, compared to 30% in the Upper West region) and primary male (85.6% in the Central region, compared to 38.6% in the Upper West region). This suggests that respondents from the Upper West region are less likely than respondents from the Central region to sell their crops on the market. Impacts on higher maize price received by the primary female are concentrated in the Central region, and the difference in impact between the Central and Upper West regions is significant. With the exception of a marginally significant negative impact on females having any sales revenue, there are no other impacts on market access or practices across the Upper West or Central region.

Table 8.13: Heterogeneity of VFC's impacts on household nutrition knowledge, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Percentage of correct answers (female)	57.948	0.442	1,785	73.126	-2.184	1,787	0.235
		(1.441)			(1.686)		
Percentage of correct answers (male)	62.080	1.226	1,375	71.918	-1.640	1,570	0.172
		(1.377)			(1.589)		
Anderson Index: nutrition combined correct percentages of females and males	-0.330	0.070	1,254	0.309	-0.112	1,477	0.089*
		(0.072)			(0.079)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.14: Heterogeneity of VFC's impacts on household farming knowledge, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Percentage of correct answers (female)	57.123	0.017	1,785	80.399	-0.114	1,787	0.917
		(0.990)			(0.788)		
Percentage of correct answers (male)	61.355	1.502	1,375	80.999	-0.147	1,570	0.212
		(0.990)			(0.881)		
Anderson Index: farming combined correct percentages of females and males	-0.690	0.048	1,254	0.569	-0.002	1,477	0.496
		(0.056)			(0.048)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.15: Heterogeneity of VFC's impacts on female's market access and practices, by geographic strata

	Mean of control, Central	Impact estimates, Central	N	Mean of control, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Had sales revenue in the 2018 major season	0.752	-0.010	1,785	0.300	-0.062*	1,787	0.298
		(0.037)			(0.035)		
Takes 30 minutes or less to get to the market where main crop is sold	0.883	0.022	1,333	0.648	-0.004	494	0.652
		(0.022)			(0.054)		
Lowest price per kilogram received for maize from the 2018 major harvest	1.526	0.225*	228	1.098	-0.143	86	0.030**
		(0.116)			(0.128)		
Highest price per kilogram received for maize from the 2018 major harvest	1.764	0.341**	226	1.234	-0.117	86	0.038**
		(0.153)			(0.164)		
Lowest price per kilogram received for cocoa from the 2018 major harvest	53.280	8.950	660	-	-	-	-
		(15.410)					
Highest price per kilogram received for cocoa from the 2018 major harvest	58.118	8.300	660	-	-	-	-
		(17.090)					
Lowest price per kilogram received for groundnut from the 2018 major harvest	-	-	-	1.827	-0.117	241	-
					(0.118)		
Highest price per kilogram received for groundnut from the 2018 major harvest	-	-	-	2.046	-0.051	240	-
					(0.147)		
Knows more than one buyer who would have been willing to buy their crop	0.790	-0.006	1,182	0.500	0.090	430	0.164
		(0.034)			(0.061)		
Reason respondent decided to sell to the main buyer: Best price	0.136	0.028	1,268	0.374	0.026	466	0.983
		(0.024)			(0.051)		
Reason respondent decided to sell to the main buyer: Immediate payment	0.520	0.000	1,268	0.453	0.019	466	0.756
		(0.041)			(0.043)		
Better price if respondent had sold this crop at a different place	0.216	0.023	1,215	0.272	0.037	354	0.836
		(0.041)			(0.057)		
Better price if respondent had sold this crop to a different buyer	0.178	0.023	1,210	0.284	0.008	342	0.830

		(0.039)			(0.058)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.16: Heterogeneity of VFC's impacts on male's market access and practices, by geographic strata

	Mean of control, Central	Impact estimates, Central	N	Mean of control, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Had sales revenue in the 2018 major season	0.856	-0.009	1,375	0.386	-0.034	1,570	0.634
		(0.030)			(0.042)		
Takes 30 minutes or less to get to the market where main crop is sold	0.916	-0.011	1,167	0.708	-0.004	591	0.879
		(0.021)			(0.046)		
Lowest price per kilogram received for maize from the 2018 major harvest	1.604	-0.079	181	1.016	-0.031	143	0.758
		(0.130)			(0.094)		
Highest price per kilogram received for maize from the 2018 major harvest	1.943	0.024	183	1.165	0.239	142	0.567
		(0.200)			(0.324)		
Lowest price per kilogram received for cocoa from the 2018 major harvest	56.647	11.872	677	-	-	-	-
		(16.411)					
Highest price per kilogram received for cocoa from the 2018 major harvest	60.886	5.262	677	-	-	-	-
		(16.121)					
Lowest price per kilogram received for groundnut from the 2018 major harvest	-	-	-	1.704	-0.117	289	-
					(0.111)		
Highest price per kilogram received for groundnut from the 2018 major harvest	-	-	-	2.191	-0.085	290	-
					(0.406)		
Knows more than one buyer who would have been willing to buy their crop	0.773	0.011	1,070	0.568	0.022	541	0.887
		(0.038)			(0.064)		
Reason respondent decided to sell to the main buyer: Best price	0.139	0.014	1,167	0.407	0.005	591	0.850
		(0.027)			(0.041)		

Reason respondent decided to sell to the main buyer: Immediate payment	0.455	0.020	1,167	0.386	0.045	591	0.653
		(0.037)			(0.043)		
Better price if respondent had sold this crop at a different place	0.159	0.037	1,097	0.469	-0.061	461	0.097*
		(0.032)			(0.050)		
Better price if respondent had sold this crop to a different buyer	0.133	0.036	1,097	0.418	-0.068	444	0.076*
		(0.033)			(0.049)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. The model controls for region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

8.3 Heterogeneity of impact by PPI

To explore heterogeneity across poverty, we interact the probability that a household is below 150% of the NPL with the indicator for being randomly offered the VFC service ('treatment'). Similarly, we interact all other control variables with the treatment indicator so that the main (non-interacted) coefficient on the treatment represents the overall average treatment effect of the VFC service and the interaction between the poverty likelihood and the treatment indicator measures how this impact changes with the baseline poverty likelihood of the household.[31] Results are presented in tables where the first column represents the treatment indicator, the second column the poverty likelihood indicator, and the last column the interaction of the treatment indicator with the poverty indicator. The coefficient on the interaction can therefore be interpreted as the additional impact of the VFC offer for households that were identified as being one percentage point more likely to be below 150% of the NPL relative to a household at the sample mean likelihood. If the coefficient on the interaction is positive, this means that the impact of being offered the VFC service increases with poverty.

8.3.1 Primary outcomes

The first columns of Table 8.17 and Table 8.18 display the effect of being offered the VFC service at the sample mean likelihood of being below the 150% NPL. As with the results found in Section 6, there are no impacts of being offered the VFC service on household or women's dietary outcomes, with the exception of a household consuming dairy. The second column displays the associations between the dietary diversity indicators and the likelihood of being below 150% of the NPL. Results are as expected: the higher the probability of being below the NPL, the lower the HDDS and the less likely that the household or woman consumes meats, eggs, dairy, and oils or fats. The third column displays the interaction of treatment and the likelihood of being below 150% of NPL. Coefficients are insignificant and close to zero, suggesting that the impact of the VFC offer on dietary diversity indicators does not vary by wealth.

Table 8.17: Heterogeneity of VFC's impacts on household dietary diversity by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
HDDS (1–12)	0.073	-0.004*	0.000	3,706
	(0.094)	(0.002)	(0.003)	
Household consumed cereals	0.012	-0.000	0.001	3,796
	(0.012)	(0.000)	(0.000)	
Household consumed roots and tubers	0.022	0.000	-0.000	3,778
	(0.017)	(0.000)	(0.001)	
Household consumed vegetables	0.014	0.001	-0.001	3,795
	(0.021)	(0.000)	(0.001)	
Household consumed fruit	-0.018	-0.001	0.000	3,789
	(0.026)	(0.001)	(0.001)	
Household consumed meat/organ meat	0.024	-0.002***	-0.000	3,779

[31] In practice, we follow Imbens and Rubin (2015) and interact the demeaned poverty likelihood and control variables with the treatment indicator while still including the unadjusted values of the characteristics as controls.

	(0.017)	(0.000)	(0.001)	
Household consumed eggs	0.010	-0.001**	-0.000	3,782
	(0.011)	(0.000)	(0.000)	
Household consumed seafood	-0.015	0.000	-0.000	3,793
	(0.018)	(0.000)	(0.001)	
Household consumed legumes, pulses, nuts, and seeds	-0.000	0.000	0.001	3,792
	(0.022)	(0.001)	(0.001)	
Household consumed dairy	0.024*	-0.001***	0.000	3,796
	(0.014)	(0.000)	(0.000)	
Household consumed oils and fats	-0.010	-0.001*	0.000	3,758
	(0.022)	(0.001)	(0.001)	
Household consumed sweets	0.008	-0.001	0.000	3,749
	(0.017)	(0.000)	(0.001)	
Household consumed condiments	0.011	0.000	-0.000	3,781
	(0.011)	(0.000)	(0.000)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.18: Heterogeneity of VFC's impacts on women's dietary diversity by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
Women's Dietary Diversity Score (1–10)	-0.041	-0.003	0.002	3,553
	(0.085)	(0.002)	(0.003)	
Met MDD-W	-0.018	-0.001	0.001	3,553
	(0.027)	(0.001)	(0.001)	
Primary female consumed tubers and grains	-0.008	0.000	0.000	3,572
	(0.007)	(0.000)	(0.000)	
Primary female consumed pulses	-0.011	-0.000	0.000	3,567
	(0.016)	(0.000)	(0.001)	
Primary female consumed dairy	0.008	-0.001***	0.001	3,572
	(0.013)	(0.000)	(0.001)	
Primary female consumed meat/fish/poultry	-0.014	-0.000	-0.000	3,572
	(0.015)	(0.000)	(0.001)	
Primary female consumed eggs	0.000	-0.001***	-0.000	3,567
	(0.011)	(0.000)	(0.000)	
Primary female consumed green leafy vegetables	-0.010	0.000	0.000	3,569
	(0.024)	(0.001)	(0.001)	
Primary female consumed vitamin A-rich fruits and vegetables	0.013	-0.000	0.000	3,571
	(0.016)	(0.000)	(0.001)	

Primary female consumed other vegetables	-0.014	-0.000	0.000	3,571
	(0.026)	(0.001)	(0.001)	
Primary female consumed other fruits	-0.014	-0.000	0.000	3,571
	(0.026)	(0.001)	(0.001)	
Primary female consumed nuts and seeds	0.012	-0.000	0.000	3,566
	(0.014)	(0.000)	(0.000)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.19 and Table 8.20 display the heterogeneity results with respect to household wealth of being offered the VFC service on agriculture outcomes. The (non-causal) associations between the crop cultivation indicators and the likelihood of being below 150% of the NPL are as expected: the higher the probability of being below the NPL, the lower the yields of maize and groundnut, the lower the total value of production, the lower the total value of production for maize and groundnut, and the lower the input costs for groundnut. There is one significant heterogeneous effect on maize yield; the impact of the VFC offer on maize yields increases by .005 for every percentage point increase in the likelihood of being below 150% of the NPL. In other words, the poorer the household, the larger the impact on maize yields.

Table 8.19: Heterogeneity of VFC's impacts on crop cultivation by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
Number of crops cultivated	0.071	0.002	0.000	3,737
	(0.079)	(0.002)	(0.002)	
Total area cultivated (acres) (log)	-0.013	0.001	0.000	3,622
	(0.039)	(0.001)	(0.001)	
Household grows maize	0.025	-0.000	0.001	3,737
	(0.019)	(0.000)	(0.001)	
Area of maize cultivated (acres) (log)	0.008	0.000	0.000	2,765
	(0.025)	(0.001)	(0.001)	
Yield of maize (kg/acre) (log)	0.019	-0.006***	0.005**	2,734
	(0.068)	(0.001)	(0.002)	
Household grows cocoa	-0.019	0.000	0.000	3,737
	(0.021)	(0.000)	(0.000)	
Area of cocoa cultivated (acres) (log)	-0.063	-0.000	-0.002	1,046
	(0.072)	(0.001)	(0.002)	
Yield of cocoa (kg/acre) (log)	-0.167	-0.003	-0.003	1,035
	(0.219)	(0.004)	(0.005)	
Household grows groundnut	0.014	0.000	0.000	3,737
	(0.018)	(0.000)	(0.001)	

Area of groundnut cultivated (acres) (log)	0.075**	0.000	0.000	1,191
	(0.037)	(0.001)	(0.001)	
Yield of groundnut (kg/acre) (log)	-0.095	-0.003*	-0.002	1,169
	(0.089)	(0.002)	(0.002)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. Variables of area, yield, value of production, and cost of production are screened for outliers: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.20: Heterogeneity of VFC's impacts on value, costs, and profits (GHS) of crop production, by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
Total value of production (IHS)	-0.068	-0.005**	0.003	3,591
	(0.122)	(0.002)	(0.003)	
Total input costs (IHS)	0.044	-0.001	-0.005	3,593
	(0.098)	(0.003)	(0.003)	
Total profit (IHS)	-0.026	-0.000	0.005	3,562
	(0.344)	(0.008)	(0.010)	
Total value of maize produced (IHS)	0.021	-0.004**	0.004	2,731
	(0.079)	(0.002)	(0.003)	
Input cost of maize (IHS)	0.031	-0.002	-0.006	2,736
	(0.115)	(0.003)	(0.004)	
Profit from maize (IHS)	-0.012	0.004	0.001	2,714
	(0.304)	(0.007)	(0.011)	
Total value of cocoa produced (IHS)	-0.603	-0.003	-0.007	1,034
	(0.439)	(0.008)	(0.010)	
Input cost of cocoa (IHS)	-0.172	-0.008	-0.000	1,038
	(0.279)	(0.005)	(0.007)	
Profit from cocoa (IHS)	0.323	0.005	-0.008	1,025
	(0.619)	(0.013)	(0.017)	
Total value of groundnut produced (IHS)	0.016	-0.004**	-0.002	1,181
	(0.116)	(0.002)	(0.003)	
Input cost of groundnut (IHS)	-0.072	-0.010**	-0.001	1,180
	(0.269)	(0.005)	(0.006)	
Profit from groundnut (IHS)	-0.720	-0.005	-0.013	1,170
	(0.492)	(0.011)	(0.016)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. Variables of

area, yield, value of production, and cost of production are screened for outliers: values that fall within the upper 1% or lower 1% of the distribution are replaced with missing values. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

8.3.2 Secondary outcomes

Table 8.21 and Table 8.22 display the heterogeneity results with respect to household wealth of being offered the VFC service on nutrition and farming knowledge. The (non-causal) associations between the nutrition or farming knowledge and the likelihood of being below 150% of the NPL are as expected: the higher the probability of being below the NPL, the lower the primary male or primary female's nutrition or farming knowledge. As with Section 6, there are no impacts of being offered the VFC service on nutrition or farming knowledge, and these results do not vary by household wealth.

Table 8.21: Heterogeneity of VFC's impacts on household nutrition knowledge by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
Percentage of correct answers (female)	-0.746	-0.051**	0.006	3,572
	(1.155)	(0.024)	(0.031)	
Percentage of correct answers (male)	-0.058	-0.087***	-0.013	2,945
	(1.092)	(0.025)	(0.033)	
Anderson Index: nutrition combined correct percentages of females and males	-0.015	-0.004***	-0.001	2,731
	(0.055)	(0.001)	(0.002)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.22: Heterogeneity of VFC's impacts on household farming knowledge by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
Percentage of correct answers (female)	-0.067	-0.020	-0.003	3,572
	(0.630)	(0.015)	(0.021)	
Percentage of correct answers (male)	0.266	-0.038**	-0.005	2,945
	(0.734)	(0.016)	(0.022)	
Anderson Index: farming combined correct percentages of females and males	0.025	-0.002*	-0.000	2,731
	(0.037)	(0.001)	(0.001)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the

PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.23 and Table 8.24 display the heterogeneity results with respect to household wealth of being offered the VFC service on the market access of the primary female and primary male, respectively. There is one marginally significant heterogeneous effect on the number of buyers that the primary female knows: the impact of the VFC offer on knowing more than one buyer increases by .002 for every percentage point increase in the likelihood of being below 150% of the NPL. In other words, the poorer the household, the larger the impact on knowing more than one buyer. For the primary male, impacts on market access are also larger for poorer households. The impact on the probability that it takes the primary male 30 minutes or less to get to the market to sell his crop is larger for poorer households (marginally significant), as is the impact on the highest price received for groundnut (significant at the 5% level).

Table 8.23: Heterogeneity of VFC's impacts on female's market access and practices by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
Had sales revenue in the 2018 major season	-0.034	0.000	0.000	3,572
	(0.025)	(0.001)	(0.001)	
Takes 30 minutes or less to get to the market where main crop is sold	0.013	-0.000	0.001	1,827
	(0.030)	(0.001)	(0.001)	
Lowest price per kilogram received for maize from the 2018 major harvest	0.058	-0.001	-0.003	314
	(0.092)	(0.003)	(0.004)	
Highest price per kilogram received for maize from the 2018 major harvest	0.108	-0.002	-0.002	312
	(0.114)	(0.003)	(0.005)	
Lowest price per kilogram received for cocoa from the 2018 major harvest	11.373	0.052	0.047	660
	(16.439)	(0.299)	(0.435)	
Highest price per kilogram received for cocoa from the 2018 major harvest	11.807	-0.050	0.199	660
	(18.140)	(0.312)	(0.455)	
Lowest price per kilogram received for groundnut from the 2018 major harvest	-0.156	-0.002	0.001	242
	(0.153)	(0.003)	(0.004)	
Highest price per kilogram received for groundnut from the 2018 major harvest	-0.087	-0.001	0.002	241
	(0.188)	(0.003)	(0.005)	
Knows more than one buyer who would have been willing to buy their crop	0.037	-0.001	0.002*	1,612
	(0.035)	(0.001)	(0.001)	
Reason respondent decided to sell to the main buyer: Best price	0.026	-0.000	-0.001	1,734
	(0.028)	(0.001)	(0.001)	
Reason respondent decided to sell to the main buyer: Immediate payment	0.007	0.000	0.000	1,734
	(0.030)	(0.001)	(0.001)	
Better price if respondent had sold this crop at a different place	0.032	0.000	0.000	1,569
	(0.035)	(0.001)	(0.001)	
Better price if respondent had sold this crop to a different buyer	0.020	0.001	-0.000	1,552
	(0.035)	(0.001)	(0.001)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 8.24: Heterogeneity of VFC's impacts on male's market access and practices by household wealth

	Treatment	Likelihood of <150% NPL	Treatment x Likelihood of <150% NPL	N
Had sales revenue in the 2018 major season	-0.014	-0.001	0.000	2,945
	(0.026)	(0.001)	(0.001)	
Takes 30 minutes or less to get to the market where main crop is sold	0.004	-0.001*	0.001*	1,758
	(0.027)	(0.001)	(0.001)	
Lowest price per kilogram received for maize from the 2018 major harvest	-0.043	-0.003	0.004	324
	(0.083)	(0.002)	(0.003)	
Highest price per kilogram received for maize from the 2018 major harvest	0.112	-0.000	-0.001	325
	(0.182)	(0.002)	(0.003)	
Lowest price per kilogram received for cocoa from the 2018 major harvest	13.014	-0.146	0.049	677
	(17.085)	(0.356)	(0.485)	
Highest price per kilogram received for cocoa from the 2018 major harvest	7.023	-0.176	0.232	677
	(16.935)	(0.364)	(0.505)	
Lowest price per kilogram received for groundnut from the 2018 major harvest	-0.264**	-0.003	0.006	289
	(0.109)	(0.003)	(0.004)	
Highest price per kilogram received for groundnut from the 2018 major harvest	-0.409	-0.014**	0.025**	290
	(0.441)	(0.007)	(0.012)	
Knows more than one buyer who would have been willing to buy their crop	0.019	-0.000	0.001	1,611
	(0.038)	(0.001)	(0.001)	
Reason respondent decided to sell to the main buyer: Best price	0.011	-0.000	-0.001	1,758
	(0.025)	(0.001)	(0.001)	
Reason respondent decided to sell to the main buyer: Immediate payment	0.030	0.000	-0.000	1,758
	(0.028)	(0.001)	(0.001)	
Better price if respondent had sold this crop at a different place	-0.024	-0.000	0.000	1,558
	(0.031)	(0.001)	(0.001)	
Better price if respondent had sold this crop to a different buyer	-0.025	0.001	-0.001	1,541
	(0.030)	(0.001)	(0.001)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Reported are impact estimates from the regressions of each outcome on the treatment indicator, likelihood of being below 150% of the NPL, and an interaction term of the latter two. The poverty likelihood is converted from the PPI using the threshold values created for Ghana. The model controls for region and value of the respective outcome at baseline. Interaction terms between treatment and demeaned control variables are added to the model. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

8.4 Summary

In this section we explored whether the impacts of the VFC offer varied by the gender of the person targeted (primary male or primary female), region (Central or Upper West), and wealth (using the likelihood of being below 150% of the NPL). We find a few differences across these dimensions. First, the targeting matters for a few aspects of dietary diversity but not agriculture, knowledge, or market outcomes. Specifically, targeting the primary female leads to her being significantly more likely to consume dairy compared to if the service was targeted to the primary male, suggesting that information about the importance of eating these types of food is not being shared from male to female.

Second, impacts on household dietary diversity vary by region; they are significantly larger in the Central region compared to the Upper West region. While there are no differences in impact across regions on any agricultural indicator, there are significant differences across region on market outcomes. Specifically, in the Central region the VFC offer leads to significantly larger impacts on maize prices received for the primary female, compared to the Upper West region.

Third, poverty matters for impacts on maize yields and market outcomes but not for diets or knowledge. In particular, impacts on maize yields and market outcomes related to the price for groundnut (primary male) are significantly larger for households that are poorer.

Although these findings give some indication that targeting and region may make a difference for impacts on diets (though not for agriculture) and that impacts on agriculture and market prices are larger for poorer households, we recognize that we have conducted many tests, and that some results may have occurred by chance.

9 Impact on mobile phone usage

In this section we explore whether the VFC service led to changes in mobile phone usage. From a business model perspective, providing agriculture and nutrition content may be cost effective if it leads to increases in subscriber numbers and airtime minutes sold. Questions on mobile phone usage were asked separately of the primary male and primary female in each household at baseline and endline. We estimate the ITT impacts of being offered the VFC service on outcomes related to reported mobile phone usage and present results first for the primary female, and then for the primary male. As with Section 6, we present tables that include the endline mean of the comparison group and the ITT estimate with basic controls and extended controls.

9.1 Mobile phone usage of the primary female

The first set of three variables analysed are those that relate to owning or having access to a mobile phone. The first column of Table 9.1 reveals that about 50% of primary females in the comparison group own a mobile phone, while 82% have access to a phone. The number of phone numbers (or SIMs) to which the primary female in the comparison group has access is approximately one at endline. The encouragement of being offered the VFC service for free has no impact on the primary female's ownership or access to mobile phones in the basic model and leads to a small, marginally significant decrease in her access to mobile phones in the extended control model.

The rest of the variables analysed apply to the subset of primary females who have access to a mobile phone. Given that the primary female in the comparison group has access to one phone number on average, the proportion of phone numbers that use Vodafone as the network provider is similar to the proportion of primary females that use Vodafone as the main network provider, which is 19.5% in the comparison group. This is about 10 percentage points lower than at baseline, suggesting that there is a trend towards using other network providers. The offer of the VFC service leads to a significant increase in the proportion of mobile phones that use Vodafone and the proportion of primary females that use Vodafone as the main network provider. The magnitude of impact is about 10 and 9 percentage points, respectively, which represents a 50% increase with respect to the comparison mean. Given the trend towards using other network providers, these increases suggest that the door-to-door free offer of the VFC service helped to dissuade users from moving to other network providers. Impacts are similar when the offer is targeted to the primary male or primary female (see Table 10.8 in Annex D), and significantly larger in the Upper West region, compared to the Central region, where rates of Vodafone network usage are higher (see Table 10.7 and Table 10.9 in Annex D).

In terms of SIM turnover, 76.6% of primary females in the comparison group have had their SIM for over a year and 83% are likely to recommend their main network provider to their friends or family. Being offered the VFC service has no impact on SIM turnover or the likelihood of recommending the main network provider to friends or family.

In the 14 days prior to the survey, a little more than half of primary females in the comparison group used their main phone every day, with the main purpose being for making or receiving calls. On average, the primary female in the comparison group spends GHS 11 on airtime across all mobile phones. There are no impacts of being offered the VFC service on using the main mobile phone to make or receive calls, send or receive text messages, or use mobile internet, or on the total amount spent on airtime. However, there is a significant negative impact on using the main mobile phone to send mobile money, but this impact is mainly from mobile phones that do not have Vodafone as the main network provider.

Table 9.1: Impact estimates of VFC on female's mobile phone use

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Owns a mobile phone	0.496	-0.009	-0.010	3572
		(0.017)	(0.017)	
Has access to a mobile phone	0.826	-0.027	-0.028*	3572
		(0.017)	(0.016)	
Number of mobile phone numbers primary female owns or has access to	0.998	-0.015	-0.014	3572
		(0.051)	(0.051)	
Fraction of mobile phone numbers that use Vodafone as network provider	0.196	0.097***	0.096***	2905
		(0.025)	(0.024)	
Main phone number uses a Vodafone SIM card	0.195	0.089***	0.090***	2905
		(0.022)	(0.022)	
Has had main phone number SIM card for over a year	0.766	0.013	0.018	2905
		(0.018)	(0.017)	
Likely or very likely to recommend main mobile phone provider	0.834	-0.001	0.003	2905
		(0.019)	(0.019)	
Used main mobile phone every day in the last 14 days	0.542	-0.024	-0.015	2905
		(0.021)	(0.020)	
Used main mobile phone in the last 14 days to make calls	0.808	-0.008	-0.002	2905
		(0.019)	(0.018)	
Used main mobile phone in the last 14 days to receive calls	0.840	0.005	0.011	2905
		(0.016)	(0.015)	
Used main mobile phone in the last 14 days to send text messages	0.036	0.000	0.001	2905
		(0.008)	(0.008)	
Used main mobile phone in the last 14 days to receive text messages	0.297	0.012	0.018	2905
		(0.024)	(0.023)	
Used main mobile phone in the last 14 days to send mobile money	0.074	-0.021**	-0.021**	2905
		(0.011)	(0.010)	
Used main mobile phone in the last 14 days to receive mobile money	0.168	-0.026*	-0.021	2905
		(0.015)	(0.014)	
Used main mobile phone in the last 14 days to use mobile internet	0.012	-0.002	-0.002	2905
		(0.004)	(0.004)	
Has ever used mobile phone to receive agricultural advice	0.019	0.054***	0.056***	2844
		(0.009)	(0.009)	
Has ever received automated text messages with information about agricultural tips, weather, market price, or nutrition	0.021	0.142***	0.146***	2799
		(0.013)	(0.013)	
Amount spent on airtime on all phones in an average month (GHS)	11.401	-0.357	-0.188	2905
		(0.593)	(0.588)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

As seen at baseline, very few primary females in the comparison group have used their mobile phone to obtain agriculture advice (2%) or have ever received text messages with information on agriculture tips, weather, market prices, or nutrition (2%). The encouragement intervention significantly increases these probabilities, by about 5 and 14 percentage points, respectively. These results reveal that the study design successfully increased the probability that females received agriculture and nutrition information via mobile phones. While there are no significant differences in impact across the Central and Upper West regions, there are significant differences across targeting the primary male or the primary female (see tables 10.7 to 10.10 in Annex D). Offering the VFC service to a primary female, compared to a primary male, leads to significantly larger increases in the probability that a primary female uses her mobile phone to receive agriculture advice or received agriculture and nutrition messages. This suggests that the targeted person is more likely to receive the information.

9.2 Primary male

Primary males' mobile phone ownership and usage is higher than the primary females' ownership and usage. On average, 78.5% of primary males in the comparison group own a mobile phone and 89.2% have access to one (Table 9.2). The average number of phone numbers (or SIMs) to which the primary male has access is a little over one at endline. As with the results for the primary female, the encouragement of being offered the VFC service has no impact on primary males' ownership or usage of mobile phones.

The proportion of mobile phone numbers that use Vodafone as the network provider and the proportion of primary males with Vodafone as the main network provider is about 22%. As with the results for the primary female, the encouragement leads to a significant increase, of 11.4 percentage points, in the proportion of mobile phones that use Vodafone and an increase of 9.4 percentage points in the proportion of primary males with Vodafone as the main network provider. These figures represent a 50% and 43% increase, respectively, compared to the comparison group mean. There are no differences in the size of the impact across targeting the offer to the primary male or primary female or across regions (see Table 10.7 and

Table 10.10 in Annex D).

In terms of SIM turnover, 89% of primary males in the comparison group have had their SIM for over a year and 91% are likely to recommend their main network provider to their friends or family. Being offered the VFC service has no impact on SIM turnover, but it significantly decreases the likelihood of recommending the main network provider to friends or family. The main network provider in 67% of cases is MTN.

In the last 14 days before the survey, almost 80% of primary males in the comparison group used their phones every day; about 94% of primary males in the comparison group used their main mobile phone to make and receive calls, 13.9% to send text messages, 56.1% to receive text messages, 20.7% to send mobile money, and 31% to receive mobile money. On average, the primary male in the comparison group spends GHS 26.86 on airtime across all mobile phones. There are no impacts of being offered the VFC service on using the main mobile phone to make or receive calls, send or receive text messages, or use mobile internet, or on the amount spent on airtime across all phones. However, as with the results for the primary female, there is a marginally significant negative impact on using the main mobile phone to send mobile money, which again is mainly for mobile phones that do not have Vodafone as the main network provider. A few significant differences in impact arise across regions, with the VFC offer leading to larger and significant impacts on the probability that the primary male uses the main mobile phone to send text messages and to use mobile internet in the Central region, compared to the Upper West region.

Table 9.2: Impact estimates of VFC on male's mobile phone use

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Owns a mobile phone	0.785	-0.016	-0.017	2945
		(0.015)	(0.014)	
Has access to a mobile phone	0.892	-0.008	-0.010	2945
		(0.014)	(0.014)	
Number of mobile phone numbers primary female owns or has access to	1.193	0.035	0.039	2945
		(0.063)	(0.061)	
Fraction of mobile phone numbers that use Vodafone as network provider	0.222	0.114***	0.114***	2626
		(0.025)	(0.024)	
Main phone number uses a Vodafone SIM card	0.217	0.094***	0.095***	2626
		(0.021)	(0.021)	
Has had main phone number SIM card for over a year	0.891	-0.014	-0.018	2626
		(0.013)	(0.013)	
Likely or very likely to recommend main mobile phone provider	0.912	-0.030*	-0.032**	2626
		(0.016)	(0.015)	
Used main mobile phone every day in the last 14 days	0.791	-0.019	-0.016	2626
		(0.020)	(0.018)	
Used main mobile phone in the last 14 days to make calls	0.936	-0.004	-0.005	2626
		(0.012)	(0.011)	
Used main mobile phone in the last 14 days to receive calls	0.942	-0.005	-0.003	2626
		(0.010)	(0.010)	
	0.139	0.007	0.015	2626

Used main mobile phone in the last 14 days to send text messages		(0.015)	(0.014)	
Used main mobile phone in the last 14 days to receive text messages	0.561	0.011	0.016	2626
		(0.022)	(0.021)	
Used main mobile phone in the last 14 days to send mobile money	0.207	-0.037**	-0.036*	2626
		(0.019)	(0.018)	
Used main mobile phone in the last 14 days to receive mobile money	0.310	-0.030	-0.032	2626
		(0.021)	(0.021)	
Used main mobile phone in the last 14 days to use mobile internet	0.051	0.010	0.013	2626
		(0.010)	(0.009)	
Has ever used mobile phone to receive agricultural advice	0.058	0.159***	0.160***	2573
		(0.019)	(0.018)	
Has ever received automated text messages with information about agricultural tips, weather, market price, or nutrition	0.072	0.384***	0.383***	2467
		(0.020)	(0.019)	
Amount spent on airtime on all phones in an average month (GHS)	26.859	-1.527	-1.712	2626
		(1.118)	(1.139)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

A slightly higher percentage of primary males in the comparison group compared to primary females have used their mobile phone to obtain agriculture advice (5.8%) or have ever received text messages with information on agriculture tips, weather, market prices, or nutrition (7.2%). The encouragement intervention significantly increases these probabilities, by about 16 and 38 percentage points, respectively, which are much larger impacts than those found for the primary female. These results reveal that the study design successfully increased the probability that males received agriculture and nutrition information via mobile phone. Impacts are larger in the Central region but the difference is only marginally significant for using the mobile phone to obtain agriculture advice. As with the results of the primary female, the targeting matters in terms of who receives the information. Offering the VFC service to a primary male compared to offering it to a female leads to significantly larger increases in the probability that a primary male uses his mobile phone to receive agriculture advice or received agriculture and nutrition messages.

9.3 Summary

On average, the door-to-door free offer of the VFC service has no impact on whether a primary male or primary female owns or has access to a mobile phone. However, offering the VFC service for free by going door-to-door leads to a significantly higher proportion of phones using Vodafone as the network provider for the primary male and the primary female. While the targeting does not matter for impacts, impacts for the primary female (but not the primary male) on using Vodafone as the network provider are significantly larger in the Upper West region compared to the Central region. This is consistent with the higher take-up rates of the VFC service in the Upper West region that were found in **Error! Reference source not found.**.

Although the encouragement attenuates an apparent decline in Vodafone subscriptions, it does not have an impact on reported mobile phone usage in terms of using the main mobile phone to make or receive calls, send or receive text messages, or use mobile internet, or on the total amount spent on airtime minutes for either the primary male or the primary female. However, it decreases the probability that a primary male or primary female uses the main mobile phone to send mobile money, although this impact is mainly for mobile phones that do not have Vodafone as the main network provider. The targeting again does not matter for impacts on usage, but in the Central region the encouragement intervention leads to significant increases in the probability that a primary male (but not female) sends text messages and uses mobile internet, and this impact is significantly larger compared to the Upper West region. These results are also consistent with the descriptive statistics in Section 5; these indicate that although registration rates are higher in the Upper West region than the Central region, once users are registered then usage is higher in the Central region.

Consistent with the services provided by the VFC, the door-to-door free offer of the service leads to significant increases in the likelihood that either the primary female or primary male uses their mobile phone to receive agriculture advice or has ever received text messages with information on agriculture tips, weather, market price, or nutrition. These impacts depend on the targeting of the offer. When the offer was targeted to the primary female, the impacts for the primary female were larger compared to when the offer was targeted to the primary male. The same is true for when the offer was targeted to the primary male, with the impacts for the primary male being larger compared to when the offer was targeted to the primary female. Consistent with the lower mobile phone usage rates of the primary female that we have seen, the impacts on the likelihood of using the mobile phone to receive agriculture or nutrition information is about three times larger for primary males than females.

10 Conclusions and policy implications

10.1 Conclusions

Although mobile technology is a promising platform for improving agriculture and nutrition outcomes, challenges remain in terms of its ability to be an effective driver of change in knowledge, behaviour, and practices related to agriculture and nutrition. The aim of the impact evaluation is to assess the impact, cost effectiveness, and commercial viability of mNutrition. The evaluation is being conducted by a consortium of researchers from Gamos, IDS, and IFPRI. The team draws on a number of methods and interlinked components to gather evidence about the impact of the VFC intervention in Ghana, including a qualitative component, a quantitative component, and a business model and cost effectiveness component.

This report presents the quantitative endline findings of the impact evaluation of the mobile agriculture service launched in Ghana under the mNutrition initiative, the VFC service. The service offers agriculture and nutrition information via voice and SMS messages, in addition to a call centre, and includes free calls to other VFC members. The quantitative component employs a randomised encouragement design to determine the causal effect of the service on dietary diversity, agricultural income, and production. Households in study communities that were randomly assigned to the encouragement treatment arm received extra encouragement to increase take-up of the VFC service, while households in communities that were randomly assigned to the comparison arm did not receive the extra encouragement activities but still had access to the nationally available VFC service. The additional marketing and promotion to encourage take-up and continued use was informed by the qualitative study and included a combination of price discounts and door-to-door marketing, which were offered to a randomly selected primary male or primary female in each household. In addition, direct sign-ups and service registration for VFC were conducted during the door-to-door promotional visits and follow-up registration visits.

To measure the quantitative impacts of the programme on dietary diversity and agriculture production, a baseline and endline survey were conducted. The baseline survey, which took place from March to May 2017, collected information on 3,936 households across 207 EAs. The endline survey, which took place from November 2018 to February 2019, successfully re-surveyed 3,802 of the same households.

The findings reveal large challenges in service take-up and use. Of the 1,901 households in the encouragement group, 68% (or 1,297 households) registered for the service, following the extensive door-to-door campaign to promote the service and facilitate sign-ups, compared to 1% in the comparison group. Despite this substantial encouragement effort to promote the service, only 49.8% of those registered for the service (or 646 households) reported that someone in the households had used the service in the previous 18 months, with usage being defined as using the VFC service in the previous 18 months to either make or receive calls, send or receive SMS, receive agriculture or nutrition information, receive weather or market price information, or call the helpline. This means that only 34% of encouragement households used the service in the previous 18 months. The main reason for the encouragement households not using the service is losing or not using the SIM, followed by not having access to a mobile phone, the latter reason being significantly more important in the Upper West region compared to the Central region and among primary females compared to primary males. To a lesser extent, phone malfunction and bad network connectivity were other frequently reported reasons for the lack of use of the service.

The findings reveal substantial challenges in maintaining active service usage. These vary by service component. Of the 646 households that used the VFC service at least once in the previous 18 months, approximately 8–11% never received any weather, market price, or agriculture/nutrition information, while 74% never called the call centre to speak to an agriculture expert. Among households that did receive the market price, weather, or agriculture/nutrition messages, approximately 45% did not always or often read the weather or market price information, and 27% did not always or often listen to the voice messages. The reasons for not actively interacting with the platform vary by component, region, and gender. For weather and market price information, which was delivered via SMS in English, the main reasons for not reading all the messages were not being able to read or not knowing English. For agriculture and nutrition tips, which were delivered via voicemail in the local language, the main reasons were weak service and not having access to a phone. For using the helpline to speak to an agriculture agent, the main reasons for not using the service were not knowing that it was available, followed by believing that there was a charge for the service. Households in the Upper West region were more likely than those in the Central region, and females were more likely than males, to report not actively reading the weather and market price information because they could not read and not listening to the agriculture and nutrition voice messages because they did not have access to a mobile phone.

Although active participation among the encouraged households is low, respondents that have used the service have quite favourable perceptions of the service for several service components. The majority indicate that they find the content of the VFC service useful, that it has changed their behaviour, and that they trust and feel confident in the information. Overall, the most useful and trusted component was the agriculture expert advice, although this was the least used and least known component, followed by the agriculture/nutrition tips. Respondents in the Central region were more likely to find the weather and agriculture/nutrition messages useful compared to respondents in the Upper West region. Overall quality ratings of the service are around 7/10. The highest quality ratings were given to agricultural and nutrition tips (7.1 out of 10 for males and 7.36 out of 10 for females). Ratings were higher in the Central region compared to the Upper West in every category and among females compared to males in seven of the eight categories, with the exception of ‘ease of use’.

Despite a difference in take-up of 67% between encouragement and comparison group households, the low active usage rates of the VFC service among households in the encouraged group makes it unsurprising that **being offered the VFC service or having used it at least once has minimal impact on household and women’s dietary diversity, agriculture production, nutrition or farming knowledge, or market access and practices**. The exceptions are marginally significant increases in the probability that a household consumes dairy, marginally significant reductions in the area of cocoa cultivated for households that produce cocoa, and significant increases in the price received for maize for the primary female.

Although there are no impacts on average of being offered the VFC service**, there are a few differences in impact across the gender of the person targeted, the region, and poverty status**. First, targeting the primary female makes her significantly more likely to consume dairy, while the same is not true if the primary male is targeted. These differences are significant, suggesting that, at least in the case of dairy consumption, targeting matters. However, targeting the primary male leads to a significantly higher maize price being received by the primary female, and although impacts across targeting the female or male are not significantly different, this does suggest that market price information is being shared from male to female.

Second, impacts on household dietary diversity and market prices are positive and significant in the Central region, but not the Upper West region, and differences across regions are significant. This is consistent with self-reported usage and perceptions of the VFC service, where households

in the Central region report reading or listening to the messages more often, find the messages more useful, and give a higher quality score to the service compared to households in the Upper West region. Lastly, poverty matters for impacts on maize yields and market outcomes, but not diets or knowledge. In particular, impacts on maize yields and price received for groundnut are larger the more likely you are to be below 150% of the NPL.

Beyond the primary and secondary outcomes, we find that the free door-to-door offer of the VFC service led to significant increases in the proportion of phone numbers that used Vodafone as the network provider (an increase of about 9.6 percentage points for the primary female and 11.4 for the primary male) and the likelihood that Vodafone was the main network provider (an increase of about 8.9 percentage points for the primary female and 9.4 for the primary male). The encouragement also led to significant increases in the likelihood that the primary female and primary male had ever used their phone to receive agriculture advice (a 5.4 percentage point increase for the primary female and a 15.9 percentage point increase for the primary male) or had ever received text messages with information on agriculture, weather, market prices, or nutrition (a 14.2 percentage point increase for the primary female and 38.4 for the primary male). This is consistent with the study design and intervention, which provided free Vodafone SIMs that sent agriculture and nutrition messages to encouraged households. The VFC service did not, however, increase usage in terms of using the main mobile phone to make or receive calls, or make or receive text messages, or on the total amount spent on airtime, and it led to a significant decrease in the probability that the primary female or primary male used the main mobile phone to send mobile money, of approximately 2.1 and 3.7 percentage points, respectively.

10.2 Policy implications

The limited impacts of the VFC service on agricultural practices, nutrition knowledge, and diet have a number of important implications for the VFC platform and related interventions to make agriculture more productive and nutrition sensitive through mobile phone applications.

First, the potential for the VFC platform to build a nutrition-sensitive dimension into its agriculture information platform derives from its ability to deliver a comprehensive suite of nutrition messages at frequent intervals to a large number of households at low cost. Initially, with only one nutrition message per month on only the profiled crop, the VFC platform fell short of this potential. The number was eventually increased to three messages per month and more general nutrition messages were added, but the partial integration of the complete set of nutrition messages into the VFC platform may have limited the platform’s impact and underscores the tension for MNOs between adding mobile applications designed primarily to build interest in the service versus supplying content intended to improve outcomes. Relatedly, there was a lack of focus in the nutrition tips on the main nutrition-related behaviour that VFC aimed to improve (i.e. dietary diversity). The reason for this is that the nutrition tips in VFC covered a large range of topic areas, including food preparation, food storage, and food and environmental hygiene, and only very few messages related to approaches to improve dietary quality or diversity.

Second, there remain practical challenges for mobile phones if they are to be an effective means of improving nutrition knowledge, behaviour, or nutrition outcomes. In contrast with more typical in-person methods of conducting behaviour change communication, whereby programme staff deliver content to beneficiaries by meeting with them directly, in order to work mobile phone-based information interventions need to ensure that targeted mobile phone numbers have access to strong network services, are activated, profiled, frequently used, charged, and accessible, and also that the desired user has the time, ability, and desire to read or listen to the delivered content.

These challenges are echoed across the evaluation components (Barnett et al., 2020) and in the wider literature (Aker et al., 2016). Across the three evaluation components, the low uptake and reach of the VFC service can be explained by shortcomings related to: (1) the available supportive infrastructure (weak network coverage or network preference); (2) limited capacity of the intended target group (due to illiteracy and lack of familiarity with voice messages); and (3) issues in the implementation and design of the programme (for example, a lack of human support to encourage trust in the service and ongoing continuous engagement). A recent review of mobile phone-enabled agricultural information services (m-Agri services) in Africa also concluded that mAgri services are more likely to fail or be abandoned if these three barriers are not considered and addressed by implementers and designers (Emeana *et al.,* 2020).

The lack of impacts makes it impossible to conclude whether a better designed and implemented service would have led to improvements in the nutrition and livelihoods of farmers. However, we have shown that a mobile phone intervention that is light touch and insufficiently engaging to promote regular use did not change agriculture and nutrition outcomes. This is not surprising given that many evaluations of agriculture and nutrition interventions show that sustained programming with multiple delivery channels is often needed to change behaviour and see impact, particularly on nutrition. Thus, mobile phone-based interventions such as VFC are unlikely to be effective as a standalone channel for promoting behaviour change; they may perform best when integrated with traditional media or in-person visits as part of a multi-level strategy. Mobile phone-based information could therefore be one part of a broad, many-pronged policy, and not the only component aiming to change nutrition behaviour and practices.

References

Aker, J. C., Ghosh, I., & Burrell, J. (2016). The promise (and pitfalls) of ICT for agriculture initiatives. *Agricultural Economics*, *47*(S1), 35–48. https://doi.org/10.1111/agec.12301

Aker, J. C., Gilligan, D. O., Hidrobo, M., Ledlie, N., & Pallonic, G. (2019). *Paying for Digital Information: Assessing Farmers' Willingness to Pay for a Digital Agriculture and Nutrition Service in Ghana*.

Barnett, I., Batchelor, S., Faith, B., Gilligan, D., Gordon, J., Hidrobo, M., Mitchell, B., Palloni, G., & Scott, N. (2020). *External evaluation of mobile phone technology-based nutrition and agriculture advisory services in Africa: Final Ghana mixed methods evaluation report*.

Barnett, I.; Faith, B.; Gordon, J. and Sefa-Nyarko, C. (2019) Mobile Phones, Agriculture, and Nutrition in Ghana: Qualitative Midline Study Report, External Evaluation of Mobile Phone Technology-Based Nutrition and Agriculture Advisory Services in Africa and South Asia, Brighton: IDS

Barnett, I., Batchelor, S., Gilligan, D., Haddad, L., Hidrobo, M., Ledlie, N., Palloni, G., Scott, N., & Shyam, T. (2017). *External evaluation of mobile phone technology-based nutrition and agriculture advisory services in Africa and South Asia*: *Inception Report*

Barnett, I., Scott, N., Batchelor, S. and Haddad, L. (2016) *Dial "N" for Nutrition? A Landscape Analysis of What We Know About m-Nutrition, m-Agriculture and m-Development*, IDS, Brighton.

Barnett, I., Srivastava, S., and Gordon, J. (2018) *External evaluation of mobile phone technology-based nutrition and agriculture advisory services in Africa and South Asia: Mobile phones, nutrition and agriculture in Ghana: Initial exploratory qualitative study repor*t. Brighton: IDS

Billings, L., Gilligan, D., Hidrobo, M., Ledlie, N., & Palloni, G. (2018). *Mobile Phones, Nutrition, and Agriculture in Ghana: Quantitative Baseline Report*.

Duflo, E., Glennerster, R., & Kremer, M. (2007). Chapter 61 Using Randomization in Development Economics Research: A Toolkit. *Handbook of Development Economics*, *4*, 3895–3962. https://doi.org/10.1016/S1573-4471(07)04061-2

Emeana, E.M.; Trenchard, L.; Dehnen-Schmutz, K. (2020) 'The Revolution of Mobile Phone-Enabled Services for Agricultural Development (m-Agri Services) in Africa: The Challenges for Sustainability'. *Sustainability*, 12,1, pp. 485-490

FAO, & FHI360. (2016). Minimum Dietary Diversity for Women- A Guide to Measurement. In *Minimum Dietary Diversity for Women: A Guide for Measurement*.

Imbens, G. W., & Rubin, D. B. (2015). *Causal inference: For statistics, social, and biomedical sciences an introduction*. Cambridge University Press. https://doi.org/10.1017/CBO9781139025751

Kennedy, G., Ballard, T., & Dop, M. (2011). Guidelines for measuring household and individual dietary diversity. In *FAO, Rome.* https://doi.org/613.2KEN

Annex A Terms of reference

Call-down Contract

Terms of Reference

PO 6420: External evaluation of mobile phone technology based nutrition and agriculture advisory services in Africa and South Asia

Introduction

DFID (Research and Evidence Division) wishes to commission an external impact evaluation of mNutrition, a mobile phone technology based nutrition and agricultural advisory service for Africa and South Asia. mNutrition is a programme supported by DFID that, through business and science partnerships, aims to build sustainable business models for the delivery of mobile phone technology based advisory services that are effective in improving nutrition and agricultural outcomes.

mNutrition is primarily designed to use mobile phone based technologies to increase the access of rural communities to nutrition and agriculture related information. The initiative aims to improve knowledge among rural farming communities especially women and support beneficial behaviour change as well as increasing demand for nutrition and agriculture extension services. The mNutrition initiative launched in September 2013 will work in 10 countries in Africa (Cote d'Ivoire, Ghana, Malawi, Mozambique, Nigeria, Tanzania, Kenya, Rwanda, Uganda, Zambia) and four countries in South Asia (Bangladesh, India, Pakistan and Sri Lanka). The desired impact of mNutrition will be improved nutrition, food security and livelihoods of the poor.

Mobile phone based services have been endorsed by WHO as an effective strategy for behaviour change and for driving adherence to anti-retroviral treatment protocols (Horvath, Azman, Kennedy and Rutherford 2012). There is currently scant evidence on the impact and cost effectiveness of mobile phone technology based services for nutrition and agriculture and on the sustainability of different business models for their provision. A rigorous evaluation of mobile phone technology based nutrition services would add significantly to the current evidence base. An external evaluation team managed by the Evaluator, independent of the programme delivery mechanism, will conduct an assessment of the impact, cost effectiveness and sustainability of mobile phone technology based information and behaviour change messages for nutrition and agriculture.

Background to mNutrition

Introduction

Undernutrition is a major challenge to human and economic development globally. It is estimated that almost one billion people face hunger and are unable to get enough food to meet their dietary needs. Agriculture is a major source of livelihood in many poor countries and the sector has a potentially critical role in enhancing health, specifically maternal and child health and nutritional status. A well-developed agriculture sector will deliver increased and diversified farm outputs (crops, livestock, non-food products) and this may enhance food and nutrition security directly through increased access to and consumption of diverse food, or indirectly through greater profits to farmers and national wealth. Better nutrition and health of farmers fosters their agricultural and economic productivity. Current agricultural and health systems and policies are not meeting current and projected future global food, nutrition and health needs.

Despite major investment in agricultural and nutrition research and its uptake and application, there is significant social and geographic inequality in who benefits from these investments. Furthermore, in many developing countries, public extension systems for agriculture, health and nutrition are inefficient, have limited capacity and have a poor track record of delivery, especially in terms of supporting women and girls and the most marginalised populations (Alston, Wyatt, Pardey, Marra and Chan-Kang 2000; Anderson 2007; IFPRI 2010; Van den Berg and Jiggins 2007).

Several research and mobile network operators (MNOs) are testing a range of information and communication technology (ICT) solutions for improving access to a wide range of information and advisory services. Mobile phone based technologies are among the most promising ICT strategies, although current initiatives in nutrition are relatively small and fragmented.

What is mNutrition?

Enhancing access to the results of nutrition and agricultural research and development is potentially critical for improving the nutrition, health and livelihoods of smallholders and rural communities. mNutrition will harness the power of mobile phone based technologies and the private sector to improve access to information on nutrition, health and agricultural practices especially for women and farmers (both male and female). Specifically, mNutrition will initiate new partnerships with business and science to deliver a range of services including:

- An open-access database of nutrition and agriculture messages for use in mobile phone based communication (for example, information and behaviour change messages on practices and interventions that are known to have a direct impact on nutrition or an indirect impact via for example agriculture);
- A suite of mobile phone based nutrition and agriculture information, extension and registration services designed to: improve knowledge and generate beneficial behaviour change in nutrition and agriculture; increase demand for nutrition, health and agriculture goods and services; register and identify target populations for support; and, using real-time monitoring, support the conduct of nutrition risk assessments by community health workers.

The impacts of mNutrition are expected to include improved nutrition, food security and livelihoods of the poor, especially women in 10 countries in Africa (Cote d'Ivoire, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda and Zambia) and 4 countries in South Asia (Bangladesh, India, Pakistan and Sri Lanka). This impact will result from the increased scale and sustainability of mobile phone based nutrition and agricultural-based information services, delivered through robust public private partnerships in each country.

mNutrition has two major outcomes. One outcome will be cost-effective, sustainable business models for mobile phone enabled nutrition and agriculture services to 3 million households in 10 countries in Africa and 4 countries in South Asia that can be replicated in other countries. Linked to this outcome, the second outcome will expect these services to result in new knowledge, behaviour change and adoption of new practices in the area of agriculture and nutrition practices among the users of these mobile phone based services.

These outcomes will be achieved through four outputs:

- Improved access to relevant mobile based health, nutrition and agricultural advisory services for 3 million poor people and community health workers across 10 SSA and 4 Asian countries;
- Launch and scaling of mobile phone based health, nutrition and agricultural advisory services targeted to poor people and community health workers;

- Generation and dissemination of high quality research and evidence on the impact, cost effectiveness and sustainability of mobile phone based advisory services in nutrition and agriculture in South Asia and SSA; and
- Development of locally relevant content for mobile phone technology based agriculture and nutrition services meeting demands from users and community health workers.

In terms of promoting behaviour change and/or adoption of new practices, mNutrition will seek to achieve changes in one or more of the following areas:

- Adoption of new agricultural practices that are nutrition sensitive, improve agricultural productivity and utilise post-harvest technologies
- Changes in nutrition practices in either one or several knowledge domains including improved maternal nutrition practices during pregnancies; infant and young child feeding practice; and micronutrient supplementation to children at risk (i.e. Vitamin A, Zinc and Oral Rehydration Solution (ORS)).

mNutrition has started implementation from September 2013. For the 2 countries selected for the impact evaluation (Tanzania and Ghana), mobile network operators and content providers have been identified through a competitive process during the first half of 2014. The MNOs and content providers started developing and launching their services during the 4th quarter of 2014 and early 2015. The mobile phone based advisory services are expected to run at least till 3rd quarter of 2018.

mNutrition Project Coordination

DFID support to mNutrition will be channelled to GSMA, as well as directly to this associated independent external impact evaluation. GSMA is a global body that represents the interests of over 800 mobile operators. GSMA already works with the major mobile operators across Africa, (including Airtel, MTN, SafariCom/VodaCom) with a collective mobile footprint of more than 67% of total African connections. GSMA has a number of existing development initiatives, including mHealth and mFarmer, that are part of GSMA's Mobile for Development which brings together mobile operator members, the wider mobile industry and the development community to drive commercial mobile services for underserved people in emerging markets. GSMA will provide technical assistance to mobile phone operators, and support new partnerships with content providers to develop and scale up new nutrition and agriculture message services. GSMA will ensure sharing of best practices and promote wider replication and uptake of effective business models.

Objective and Main Questions

The objective of this work is to conduct an external evaluation of the impacts and cost effectiveness of the nutrition and agriculture advisory services provided by mNutrition compared to alternative advisory services available in the two selected countries (Ghana and Tanzania), with particular attention paid to gender and poverty issues. The impact assessment is required to answer the following questions that relate to impact, cost effectiveness and commercial viability:

- What are the impacts and cost effectiveness of mobile phone based nutrition and agriculture services on nutrition, health and livelihood outcomes, especially among women, children and the extreme poor?
- How effective are mobile phone based services in reaching, increasing the knowledge, and changing the behaviour, of the specific target groups?
- Has the process of adapting globally agreed messages to local contexts led to content which is relevant to the needs of children, women and poor farmers in their specific context?

- What factors make mobile phone based services effective in promoting and achieving behaviour change (if observed) leading to improved nutrition and livelihood outcomes?
- How commercially viable are the different business models being employed at country level?
- What lessons can be learned about best practices in the design and implementation of mobile phone based nutrition services to ensure a) behaviour change and b) continued private sector engagement in different countries?

Further evaluation questions related to other aims of mNutrition will be addressed in at least 1 country (either Ghana and/or Tanzania):

- Are mobile phone based services a cost-effective way to register and identify at risk populations to target with nutrition support?
- Are mobile phone based services a cost-effective way for community health workers to improve the quality and timeliness of data surveillance (a core set of nutrition-related indicators)?

The content for the mobile phone based advisory services will be based on international best practices and widely endorsed protocols (i.e. by the World Health Organisation) and evidence-based nutrition-sensitive agricultural practices identified by international experts. Through an iterative multi-stakeholder process, international and country experts will localise and adapt the content to make it relevant to the specific target audience in the 14 countries. The adapted content and nature of messages is expected to vary across specific target audiences within and across countries. The main purpose of assessing the relevance of the content is not to evaluate the overall health and nutrition content but on how this content has been localised and adapted and to what extent the needs of the specific target groups within their particular context have been met.

In assessing the commercial viability, it is recognised that evaluating the sustainability/long-term financial viability of the mobile phone based advisory services will be difficult as mobile network operators may not be willing to provide this potentially commercially sensitive information. Therefore, GSMA will provide support through its access to aggregated confidential financial results of the mobile network operators providing the service. GSMA will provide a financial summary report on the commercial viability of the business models without compromising the commercial sensitivity of the data for the mobile network operators. The evaluator will assess and validate commercial sustainability through an analysis of the aggregated information provided by GSMA and additional qualitative business analysis approaches.

The Evaluator has the option of proposing refinements of the existing evaluation questions during the inception phase as part of developing the research protocol. These suggestions will be considered by the Steering Committee and an independent peer review during the review of the research protocol as part of the inception phase.

Output

The output of this work will be new and robust evidence on the impact, cost effectiveness and commercial viability of mobile phone based advisory services focusing on nutrition and agriculture delivered by public and private partners, and including the development of robust methodological approaches to impact assessment of phone based advisory services.

Recipient

The primary recipient of this work will be DFID, with the beneficiaries being GSMA, governments, international agencies, foundations, MNOs and other private companies and civil society involved in policies and programmes in nutrition and agriculture that are aimed at improving nutritional,

health and agricultural outcomes. The findings of this impact evaluation are intended as global public goods.

Scope and timeline

The scope of this work is to:

- Develop a research protocol for the external evaluation of mNutrition;
- Design and undertake an external evaluation of mNutrition in two countries: Ghana and Tanzania;
- Contribute to the communication of the learning agenda, evaluation strategy and evaluation results.

The evaluation will be in two of the 14 mNutrition target countries; Ghana and Tanzania. These countries have been selected based on the phased start-up of mNutrition service activities. The focus and approach in the two respective countries will be different allowing for a comparison of the effectiveness of approaches applied. In Tanzania, mNutrition will focus on mobile phone technology based nutrition and health services and registration and identification of target population. In Ghana, the mobile phone technology will focus on nutrition and agriculture sensitive services.

In terms of coverage in number of people being targeted for these services, in total 3 million people will be reached through mNutrition; including 2 million for nutrition-sensitive agriculture advisory messages in 4 Asian and at least 2 African countries and about 1 million beneficiaries for mobile phone based nutrition services in 10 countries in SSA.

The evaluation contract period will be September 2014 to 31st December 2019. The development of the research protocol must be completed by month 4 for review and approval by DFID. Full details on tasks and deliverables are provided in sections below.

Statement on the design of the mNutrition evaluation

The evaluation design is expected to measure the impact, cost effectiveness and commercial viability of mNutrition, using a mixed-methods evaluation design and drawing on evidence from two case study countries and the M&E system of the programme. Overall, the proposed design should ensure that the evidence from the two case study countries has high internal validity and addresses the priority evidence gaps identified in the Business Case. Being able to judge the generalisability/replicability of lessons learned from the programme is of equal importance and so a credible approach to generalisation and external validity will be an important component of the overall evaluation design. The final evaluation design and methodology to generate robust evidence will be discussed in detail with DFID and GSMA before implementation.

For assessing cost effectiveness, the Evaluator will further fine-tune their proposed evaluation approach and outline their expectations in terms of data they will require from implementers. A theory based evaluation design, using mixed methods for evaluating the impact has been proposed. During the inception phase, the Evaluator will put forward a robust evaluation design for the quantitative work, either an experimental or a quasi-experimental method, with a clear outline of the strengths and limitations of the proposed method relative to alternatives. During the inception phase, the Evaluator is also expected to identify clearly what will be the implications of the design for implementers in terms of how the overall programme would be designed and implemented and for evidence to be collected in the programme's monitoring system. The Evaluator will also assess the degree to which it is realistic to assess impacts by early 2019 for a

programme where implementation started mid-2015 and, if there are challenges, how these would be managed.

The Evaluator, in its 6 monthly reports, will be required to provide information to feed into the DFID Annual Review and Project Completion Report of mNutrition.

Gender and inclusiveness

The impact evaluation will pay particular attention to gender and other forms of social differentiation and poverty issues. From current experiences, it is clear that access to and use of mobile services is differentiated along a range of factors, including gender, poverty, geographic marginalisation, education and illiteracy levels. Therefore, the impact evaluation will look at and analyse differentiated access to and potential utilisation of mobile phone based services for improved nutrition and agricultural production. Based on the findings, it will identify opportunities and challenges in having an impact on women in general and more specifically the poor and the marginalised.

Tasks

The Evaluator will perform the following tasks:

A. Finalise a coherent and robust evaluation approach and methodology based on their proposal (inception phase)

- Conduct landscape analysis of existing experiences in mobile phone based services for nutrition and agriculture based on available publications and grey project documents to identify additional critical lessons and priorities for evidence gathering and programme design and implementation;
- Ensure that gender issues and poverty issues are well integrated into the impact evaluation design;
- Develop robust sampling frameworks, core set of indicators and research protocols that allow the consistent measurement and comparison of impacts across study countries, taking into account differences in business models and programmes as needed;
- Work closely with mNutrition service team in GSMA to familiarise them with impact assessment methodology, discuss evaluation approaches, identify and agree on data provided by programme monitoring system and possible modifications to design;
- Identify risks to the evaluation meeting its objectives and how these risks will be effectively managed;
- Review existing evaluation questions and if deemed relevant propose refinement of existing questions and/or add other questions;
- Prepare a research protocol, including an updated workplan, project milestones and budget. The research protocol will be subject to an independent peer review organised by DFID; and
- Develop a communication plan.

B. Implement and analyse evaluations of impact, cost effectiveness and commercial viability in accordance with established best practices

- Based upon the agreed evaluation framework, develop and test appropriate evaluation instruments which are likely to include data collection forms for households, community health workers, service providers including health and agricultural services, content providers and private sector stakeholders including mobile network operators. Instruments will involve both quantitative and qualitative methods;

- Register studies on appropriate open access study registries and publish protocols of studies where appropriate;
- Conduct baselines and end-lines, qualitative assessments and business model assessments in both of the two impact evaluation countries;
- Conduct and analyse the evaluations and present findings in two well-structured reports addressing the evaluation questions. The reports should follow standard reporting guidelines as defined by, for example, the Equator Network. Primary findings should be clearly presented along with a detailed analysis of the underlying reasons why the desired outcomes were/were not achieved;
- The Evaluating Organisation or Consortium may subcontract the administration of surveys and data entry, but not the supervision of those tasks, study design, or data analysis; and
- The country-specific mixed-methods evaluation reports, cost effectiveness and business models studies and final evaluation report will be subject to an independent peer review organised by DFID.

C. Contribute to the communication of the learning agenda, impact evaluation strategy, and evaluation results.

- Develop a communication plan outlining the main outputs and key audiences;
- Conduct lessons learnt workshops in each of the 2 impact evaluation countries and key dissemination events; and
- Assist in communicating the results of the evaluation and contribute to the development and communication of lessons learnt about mobile phone based extension approaches in nutrition and agriculture.

Deliverables

The Evaluator will deliver the following outputs:[32]

During the design and study inception phase of maximum 4 months:

- A publishable landscape analysis report highlighting lessons learnt from existing initiatives on mobile phone based advisory services related to nutrition and agriculture by month 4;
- A updated work plan with project milestones and budget by end of month 1 (possibly adjusted based on the approved research protocol by month 4);
- A communication plan outlining the key outputs, audience and timeline for review and approval by month 4; and
- A full research protocol by month 4 for review and approval. The research protocol should be registered with appropriate open access study registries;

Interim reports:

- 4 biannual progress reports for the External Evaluation as a whole, and for each country evaluation, against milestones set out in the workplan;
  - Two desk reviews submitted by June 2016
  - Two Baseline quantitative reports submitted by April 2017
  - Two Baseline qualitative reports submitted by February 2017
  - Two Cost effectiveness reports 1 submitted by March 2017

[32] Exact timeframe of deliverables will be agreed on during the design phase as appropriate.

  - Two Business Model reports 1 submitted by March 2017
  - Two Mixed Methods Baseline reports completed by September 2017
  - Two Midline qualitative reports submitted by March 2018
- All survey data collected during the evaluation provided in a suitable format to DFID for public release.

At project's end:

- Two Endline quantitative reports submitted by June 2019
- Two Endline qualitative reports submitted by August 2019
- Two Cost effectiveness report 2 submitted by July 2019
- Two Business Model report 2 submitted by July 2019
- Two Evaluation reports submitted by October 2019
- At least 1 article, based on the findings from the country evaluation reports, published in a research journal;
- A shared lesson learnt paper published and at least one presentation highlighting key lessons for similar initiatives of promoting mobile based technologies for providing extension services and the promotion of uptake of technologies by December 2019.

Research protocol and all final reports will be independently peer reviewed. This will be organised by DFID. Outputs are expected to be of sufficiently quality so that a synthesis of findings can be published in a leading peer-reviewed journal.

Coordination and reporting requirements

A mNutrition Advisory Group (AG) will be established for the programme which will a) provide technical oversight and b) maximise the effectiveness of the programme. The Advisory Group will meet on a bi-annual basis and comprises of representatives of DFID, NORAD and GSMA representatives and independent technical experts. The Evaluator will be managed by DFID on behalf of the mNutrition Advisory Group. The Evaluator will work closely with the mNutrition service team in GSMA and its specific country implementing partners. The Evaluator will:

- Ensure coherence and lesson learning across all pilot impact assessments on the key evaluation questions and indicators identified.
- Incorporate a clear code of ethics; incorporate plans for open access publications and public access to data sets.

The Evaluator will work closely with the mNutrition project management team, in particular in the design of the overall evaluation framework and the evaluation plan for the specific project components and the countries selected for the evaluation. Collaboration and regular communication between Evaluator and mNutrition project management team and implementing partners in selected case study countries is crucial as the evaluation design may have implications for project implementation and vice versa. The mNutrition project management team will lend support in communication as requested by the Evaluator or the Advisory Group. The Evaluator will report directly to DFID who will manage the evaluation on behalf of the mNutrition Advisory Group. The main point of contact for technical matters is Louise Horner, Livelihoods Adviser and Hugh McGhie, Deputy Programme Manager for all other project related issues. The mNutrition Advisory Group will be the arbiter of any disputes between the evaluation function and the overall programme implementation.

At the end of each 6 months, the Evaluator will submit a brief report outlining key achievements against the agreed deliverables. Pre-agreed funding will then be released provided that deliverables have been achieved.

In addition to the 6 monthly reports outlined above, the Evaluator will provide information to feed into the DFID Annual Review of mNutrition. The 6 monthly reports will be a key source of information used to undertake the Annual Review and Project Completion Report for the programme. These reviews will be led by the Livelihoods Adviser and Deputy Programme Manager, in consultation with the mNutrition AG. All reviews will be made available publicly in line with HMG Transparency and Accountability Requirements.

Mandatory financial reports include an annual forecast of expenditure (the budget) disaggregated monthly in accordance with DFID's financial year April to March. This should be updated at least every quarter and any significant deviations from the forecast notified to DFID immediately. In addition the Evaluator will be required to provide annual audited statements for the duration of the contract.

Contractual Arrangements

The contract starts in September 2014 and will run till end of December 2019 subject to satisfactory performance as determined through DFID's Annual Review process. Progression is subject to the outcome of this review, strong performance and agreement to any revised work plans or budgets (if revisions are deemed appropriate).

A formal break clause in the contract is included at the end of the inception period. Progression to the implementation phase will be dependent on strong performance by the Evaluator during the inception period and delivery of all inception outputs, including a revised proposal for implementation period. Costs for implementation are expected to remain in line with what has been agreed upon for this contract, with costs such as fee rates fixed for contract duration. DFID reserves the right to terminate the contract after the inception phase if it cannot reach agreement on the activities, staffing, budget and timelines for the implementation phase.

DFID reserves the right to scale back or discontinue this assignment at any point (in line with our Terms and Conditions) if it is not achieving the results anticipated. The Evaluator will be remunerated on a milestone payment basis. DFID has agreed an output based payment plan for this contract, where payment will be explicitly linked to the Evaluator's performance and effective delivery of programme outputs as set out in the ToR and approved workplan. The payment plan for the implementation phase will be finalised during the inception period.

Open Access

The Evaluator will comply with DFID's Enhanced and Open Access Policy. Where appropriate the costs of complying with out open access policy should be clearly identified within your commercial proposal.

Branding

The public has an expectation and right to know what is funded with public money. It is expected that all research outputs will acknowledge DFID support in a way that is clear, explicit and which fully complies with DFID Branding Guidance. This will include ensuring that all publications acknowledge DFID's support. If press releases on work which arises wholly or mainly from the project are planned this should be in collaboration with DFID's Communications Department.

Duty of Care

The Evaluator is responsible for the safety and well-being of their Personnel (as defined in Section 2 of the Contract) and Third Parties affected by their activities under this contract, including appropriate security arrangements. The Evaluator is responsible for the provision of suitable security arrangements for their domestic and business property. DFID will share available information with the Evaluator on security status and developments in-country where appropriate.

The Evaluator is responsible for ensuring appropriate safety and security briefings for all of their Personnel working under this contract and ensuring that their Personnel register and receive briefing as outlined above. Travel advice is also available on the FCO website and the Evaluator must ensure they (and their Personnel) are up to date with the latest position.

The Evaluator has confirmed that:

- The Evaluator fully accepts responsibility for Security and Duty of Care.
- The Evaluator understands the potential risks and have the knowledge and experience to develop an effective risk plan.
- The Evaluator has the capability to manage their Duty of Care responsibilities throughout the life of the contract.

Annex B IRB approvals

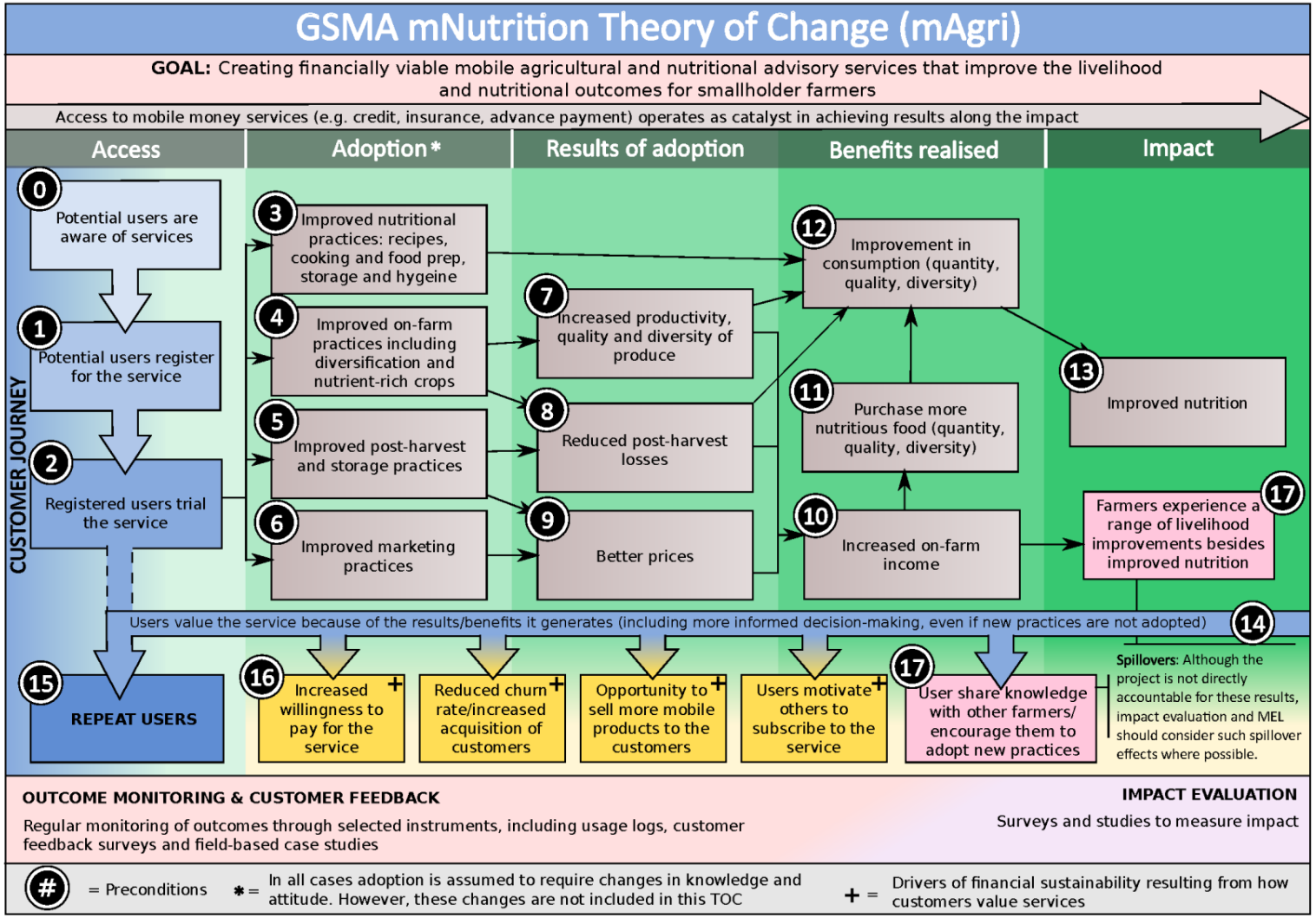
B.1 University of Ghana IRB

B.2 IFPRI IRB

B.3 IDS IRB

Please note: attachments to B1, B2 and B3 removed to meet GDPR regulations.

Annex C GSMA's Theory of Change



Source: GSMA (2016) reproduced with permission

Annex D Supplementary tables

D.1 Programme exposure

Table 10.1: Exposure to different types of VFC content within encouraged group, by region and respondent's gender

	N	All	Central	Upper West	P-value	Female respondent	Male respondent	P-value
Weather information								
Has received messages with weather info	646	0.920	0.860	0.971	0.000	0.934	0.899	0.106
		(0.272)	(0.347)	(0.168)		(0.248)	(0.301)	
Reads the messages with weather info less frequently than always or often	594	0.448	0.355	0.520	0.000	0.462	0.428	0.475
		(0.498)	(0.479)	(0.500)		(0.499)	(0.496)	
Hasn't read all the weather messages because cannot read	273	0.407	0.323	0.451	0.045	0.463	0.324	0.043
		(0.492)	(0.470)	(0.499)		(0.500)	(0.470)	
Hasn't read all the weather messages because doesn't know English	273	0.366	0.404	0.349	0.367	0.384	0.343	0.573
		(0.483)	(0.493)	(0.478)		(0.488)	(0.477)	
Hasn't read all the weather messages because of no phone access	273	0.117	0.071	0.143	0.082	0.104	0.130	0.589
		(0.322)	(0.258)	(0.351)		(0.306)	(0.337)	
Hasn't read all the weather messages because of too many messages	273	0.044	0.091	0.017	0.012	0.018	0.083	0.021
		(0.205)	(0.289)	(0.130)		(0.134)	(0.278)	
Hasn't read all the weather messages because information isn't useful	273	0.015	0.040	0.000	0.043	0.000	0.037	0.049
		(0.120)	(0.198)	(0.000)		(0.000)	(0.190)	
Hasn't read all the weather messages because mistook it for spam	273	0.026	0.020	0.029	0.644	0.006	0.056	0.027
		(0.158)	(0.141)	(0.167)		(0.078)	(0.230)	
Hasn't read all the weather messages because of other reason	273	0.026	0.051	0.011	0.076	0.024	0.028	0.865
		(0.158)	(0.220)	(0.107)		(0.155)	(0.165)	
Market price information								
Has received messages with market price info	646	0.892	0.828	0.945	0.000	0.893	0.888	0.850

		(0.311)	(0.378)	(0.229)		(0.309)	(0.315)	
Reads the messages with market price info less frequently than always or often	576	0.458	0.400	0.503	0.018	0.462	0.449	0.797
		(0.499)	(0.491)	(0.501)		(0.499)	(0.498)	
Hasn't read all the market price messages because cannot read	273	0.399	0.315	0.452	0.027	0.452	0.333	0.070
		(0.491)	(0.467)	(0.499)		(0.499)	(0.473)	
Hasn't read all the market price messages because doesn't know English	273	0.344	0.333	0.355	0.779	0.389	0.289	0.106
		(0.476)	(0.474)	(0.480)		(0.489)	(0.456)	
Hasn't read all the market price messages because of no phone access	273	0.073	0.056	0.084	0.322	0.096	0.044	0.075
		(0.261)	(0.230)	(0.279)		(0.295)	(0.206)	
Hasn't read all the market price messages because information isn't useful	273	0.055	0.130	0.006	0.000	0.006	0.123	0.001
		(0.228)	(0.337)	(0.078)		(0.080)	(0.330)	
Hasn't read all the market price messages because of too many messages	273	0.040	0.046	0.036	0.690	0.006	0.079	0.006
		(0.197)	(0.211)	(0.187)		(0.080)	(0.271)	
Hasn't read all the market price messages because mistook it for spam	273	0.018	0.028	0.012	0.386	0.013	0.026	0.453
		(0.134)	(0.165)	(0.109)		(0.113)	(0.161)	
Hasn't read all the market price messages because has other sources for prices	273	0.018	0.028	0.012	0.383	0.019	0.018	0.923
		(0.134)	(0.165)	(0.109)		(0.137)	(0.132)	
Hasn't read all the market price messages because of other reasons	273	0.051	0.065	0.042	0.382	0.019	0.088	0.012
		(0.221)	(0.247)	(0.202)		(0.137)	(0.284)	
Agriculture and nutrition tips								
Has received messages with agriculture and nutrition tips	646	0.901	0.854	0.942	0.000	0.885	0.921	0.199
		(0.299)	(0.354)	(0.235)		(0.319)	(0.270)	
Listens to the messages with agriculture and nutrition tips less frequently than often or always	582	0.270	0.179	0.344	0.000	0.262	0.273	0.789
		(0.444)	(0.384)	(0.476)		(0.441)	(0.447)	
Hasn't listened to agriculture and nutrition tips messages because of no phone access	165	0.200	0.135	0.228	0.085	0.253	0.145	0.073
		(0.401)	(0.345)	(0.421)		(0.437)	(0.354)	
Hasn't listened to agriculture and nutrition tips messages because of too many messages	165	0.145	0.058	0.184	0.019	0.138	0.158	0.703
		(0.354)	(0.235)	(0.389)		(0.347)	(0.367)	
Hasn't listened to agriculture and nutrition tips messages because of weak service	165	0.133	0.096	0.158	0.357	0.115	0.158	0.478
		(0.341)	(0.298)	(0.366)		(0.321)	(0.367)	

Hasn't listened to agriculture and nutrition tips messages because of bad timing	165	0.115	0.173	0.088	0.179	0.115	0.118	0.950
		(0.320)	(0.382)	(0.284)		(0.321)	(0.325)	
Hasn't listened to ag and nutrition tips messages because language not understandable	165	0.097	0.173	0.061	0.117	0.138	0.053	0.125
		(0.297)	(0.382)	(0.241)		(0.347)	(0.225)	
Hasn't listened to ag and nutrition tips messages because information isn't useful	165	0.036	0.096	0.009	0.028	0.023	0.039	0.559
		(0.188)	(0.298)	(0.094)		(0.151)	(0.196)	
Hasn't listened to ag and nutrition tips messages because mistook it for spam	165	0.030	0.058	0.018	0.265	0.023	0.039	0.554
		(0.172)	(0.235)	(0.132)		(0.151)	(0.196)	
Hasn't listened to ag and nutrition tips messages because has other sources	165	0.006	0.000	0.009	0.329	0.011	0.000	0.327
		(0.078)	(0.000)	(0.094)		(0.107)	(0.000)	
Hasn't listened to ag and nutrition tips messages because of other reasons	165	0.236	0.212	0.246	0.661	0.184	0.289	0.202
		(0.426)	(0.412)	(0.432)		(0.390)	(0.457)	
Helpline – agricultural expert								
Has used VFC service to speak with an agricultural expert	646	0.362	0.399	0.327	0.097	0.352	0.378	0.542
		(0.481)	(0.491)	(0.470)		(0.478)	(0.486)	
Didn't speak with an expert because didn't know about the service	412	0.316	0.395	0.247	0.002	0.316	0.312	0.940
		(0.465)	(0.490)	(0.432)		(0.466)	(0.465)	
Didn't speak with an expert because thought it would cost	412	0.148	0.119	0.177	0.232	0.156	0.139	0.667
		(0.356)	(0.325)	(0.383)		(0.364)	(0.347)	
Didn't speak with an expert because of not needing it	412	0.170	0.200	0.147	0.159	0.143	0.208	0.109
		(0.376)	(0.401)	(0.355)		(0.351)	(0.407)	
Didn't speak with an expert because of bad connectivity	412	0.085	0.043	0.117	0.012	0.084	0.087	0.939
		(0.279)	(0.204)	(0.322)		(0.279)	(0.282)	
Didn't speak with an expert because of other reasons	412	0.282	0.243	0.312	0.098	0.300	0.254	0.359
		(0.450)	(0.430)	(0.464)		(0.459)	(0.437)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means: 1) between Central and Upper West regions; and 2) between male and female respondents. Included are respondents from the encouraged group who indicated using the service over the preceding 18 months. Indicator variables for having used weather messages, market price messages, and agriculture/nutrition messages are constructed from a question “How often do (or did) you receive automates messages with information on [subject]?” and take value 1 if a respondent said “don’t know” as the question was only asked from people who previously indicated having used VFC service in previous 18 months, and these same people replied to follow-up questions on frequency of use. This occurred for approximately 5–10% of observations, depending on the component.

Source: Authors’ own

Table 10.2: Reported quality scores, by region and targeted gender

	N	All	Central	Upper West	P-value	Female respondent	Male respondent	P-value
Score (1–10): Registering, profiling, and activating	624	7.199	7.598	6.817	0.001	7.291	7.081	0.290
		(2.098)	(2.079)	(2.042)		(2.105)	(2.094)	
Score (1–10): Quality of customer service	625	7.182	7.639	6.753	0.000	7.293	7.044	0.217
		(2.110)	(1.993)	(2.122)		(2.067)	(2.163)	
Score (1–10): Ease of VFC use	625	7.053	7.508	6.623	0.000	7.043	7.066	0.903
		(2.178)	(2.119)	(2.147)		(2.216)	(2.138)	
Score (1–10): Quality of weather information	603	7.066	7.429	6.742	0.005	7.244	6.845	0.074
		(2.300)	(2.299)	(2.247)		(2.196)	(2.416)	
Score (1–10): Quality of market price information	592	6.801	6.835	6.769	0.784	7.012	6.533	0.031
		(2.411)	(2.634)	(2.201)		(2.358)	(2.463)	
Score (1–10): Quality of agriculture and nutrition tips	609	7.246	7.628	6.899	0.004	7.363	7.101	0.226
		(2.283)	(2.275)	(2.231)		(2.259)	(2.316)	
Score (1–10): Quality of farmer help line	545	6.794	7.219	6.432	0.001	6.891	6.680	0.269
		(2.490)	(2.475)	(2.443)		(2.515)	(2.462)	
Score (1–10): Overall experience	617	6.934	7.400	6.502	0.000	7.012	6.837	0.415
		(2.275)	(2.180)	(2.282)		(2.232)	(2.334)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard deviations are in parentheses. P-values are from the tests of difference of means: 1) between Central and Upper West regions; and 2) between male and female respondents. Included are respondents from the encouraged group who indicated using the service over the preceding 18 months.

Source: Authors' own

D.2 ITT impact estimates

Table 10.3: Impact estimates of VFC on female's nutrition knowledge (individual indicators)

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Knows it's very important to wash hands before preparing or eating food	0.849	-0.017	-0.016	3572
		(0.019)	(0.018)	
Knows perishable foods should be kept in refrigerator/cold place	0.929	0.008	0.007	3572
		(0.011)	(0.011)	
Knows part of the hand where most of the germs are found is under the fingernails	0.808	-0.004	-0.004	3572
		(0.020)	(0.019)	
Knows water must not be used to clean tubers because of increased susceptibility of infection	0.666	0.016	0.017	3572
		(0.027)	(0.027)	
Knows avocado is an appropriate food to feed babies when first introducing solid foods	0.634	-0.011	-0.015	3572
		(0.026)	(0.026)	
Knows eating eggs while pregnant will not make the baby a thief	0.803	-0.001	-0.000	3572
		(0.017)	(0.017)	
Knows eating fresh or tinned sardines is not bad for you	0.692	-0.005	-0.005	3572
		(0.026)	(0.025)	
Knows that the nutrient in milk that helps children build strong bones is calcium	0.289	-0.028	-0.027	3572
		(0.023)	(0.023)	
Knows that eggs are an excellent source of protein	0.571	0.001	0.000	3572
		(0.019)	(0.019)	
Knows that adding pulse flour to porridge gives the food more protein	0.416	-0.045	-0.047*	3572
		(0.028)	(0.028)	
Knows that chickens are an excellent source of protein	0.550	-0.013	-0.014	3572
		(0.021)	(0.021)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 10.4: Impact estimates of VFC on male's nutrition knowledge (individual indicators)

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Knows it's very important to wash hands before preparing or eating food	0.832	-0.015	-0.015	2945
		(0.020)	(0.020)	
Knows perishable foods should be kept in refrigerator/cold place	0.921	0.006	0.006	2945
		(0.012)	(0.012)	
Knows part of the hand where most of the germs are found is under the fingernail	0.816	-0.014	-0.015	2945
		(0.019)	(0.019)	

Knows water must not be used to clean tubers because of increased susceptibility of infection	0.707	-0.007	-0.007	2945
		(0.026)	(0.026)	
Knows avocado is an appropriate food to feed babies when first introducing solid foods	0.582	0.035	0.033	2945
		(0.027)	(0.027)	
Knows eating eggs while pregnant will not make the baby a thief	0.792	0.008	0.009	2945
		(0.018)	(0.018)	
Knows eating fresh or tinned sardines is not bad for you	0.693	0.008	0.009	2945
		(0.027)	(0.026)	
Knows that nutrient in milk that helps children build strong bones is calcium	0.307	-0.024	-0.022	2945
		(0.024)	(0.023)	
Knows that eggs are an excellent source of protein	0.668	-0.010	-0.008	2945
		(0.018)	(0.018)	
Knows that adding pulse flour to porridge gives the food more protein	0.437	-0.010	-0.012	2945
		(0.029)	(0.028)	
Knows that chickens are an excellent source of protein	0.641	-0.013	-0.012	2945
		(0.019)	(0.019)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 10.5: Impact estimates of VFC on female's farming knowledge (individual indicators)

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Knows rectangular spacing is the best for making full use of all available sun	0.720	-0.005	-0.007	3572
		(0.019)	(0.019)	
Knows the main problem caused by weeds is lower yield	0.868	-0.018	-0.018	3572
		(0.015)	(0.015)	
Knows the most likely cause of post-harvest loss of crops is mould	0.812	-0.021	-0.022	3572
		(0.018)	(0.018)	
Knows what to top dress maize with one month after planting	0.619	0.008	0.008	3572
		(0.019)	(0.019)	
Knows maize is ready to harvest for eating when tassels begin to dry	0.962	0.000	0.001	3572
		(0.007)	(0.006)	
Knows one can test if maize is dry by putting it in a bottle with salt	0.183	0.010	0.011	3572
		(0.022)	(0.022)	
Knows after harvest, cassava tubers can be stored in a pit for at least a year	0.024	-0.008	-0.007	1782
		(0.009)	(0.009)	
Knows sorting cassava by size after cleaning would help maximise profit on sales	0.867	-0.002	-0.006	1782
		(0.023)	(0.023)	
Knows drying should be avoided during cassava harvest to ensure healthy cutting	0.796	0.023	0.026	1782
		(0.034)	(0.034)	

Knows jute sack or other ventilated bag should be used to store cocoa after harvesting	0.884	-0.003	-0.003	1782
		(0.025)	(0.025)	
Knows that Capsids' control for cocoa should start between August and September	0.283	-0.039	-0.043	1782
		(0.032)	(0.031)	
Knows that cocoa harvesting should happen one to three weeks after pods are ripe	0.497	0.012	0.010	1782
		(0.048)	(0.048)	
Knows burning groundnut fields after harvest decreases crop yield	0.921	0.004	0.002	1787
		(0.016)	(0.016)	
Knows that groundnut can be stored for more than a year	0.858	-0.003	0.000	1787
		(0.025)	(0.024)	
Knows groundnut pods are mature when the vines turn yellow and leaves begin to shed	0.917	0.008	0.009	1787
		(0.015)	(0.015)	
Knows to enable millet plants to stand firm, one can raise a heap of sand around the base	0.933	-0.014	-0.015	1787
		(0.016)	(0.016)	
Knows that millet should be planted at a depth of 3–4 cm	0.390	0.019	0.026	1787
		(0.028)	(0.027)	
Knows that millet should not be grown on water-logged soil	0.795	0.052**	0.050**	1787
		(0.023)	(0.023)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 10.6: Impact estimates of VFC on male's farming knowledge (individual indicators)

	Comparison mean	Impact estimates, basic controls	Impact estimates, extended controls	N
Knows rectangular spacing is the best for making full use of all available sun	0.768	-0.004	-0.006	2945
		(0.019)	(0.019)	
Knows the main problem caused by weeds is lower yield	0.851	0.005	0.005	2945
		(0.018)	(0.018)	
Knows the most likely cause of post-harvest loss of crops is mould	0.830	-0.003	-0.003	2945
		(0.016)	(0.016)	
Knows what to top dress maize with one month after planting	0.714	0.013	0.016	2945
		(0.022)	(0.022)	
Knows maize is ready to harvest for eating when tassels begin to dry	0.968	-0.004	-0.003	2945
		(0.008)	(0.008)	
Knows one can test if maize is dry by putting it in a bottle with salt	0.206	0.011	0.016	2945
		(0.023)	(0.022)	
Knows after harvest, cassava tubers can be stored in a pit for at least a year	0.016	-0.004	-0.006	1373
		(0.008)	(0.008)	
Knows sorting cassava by size after cleaning would help maximise profit on sales	0.866	0.004	0.001	1373
		(0.025)	(0.025)	

Knows drying should be avoided during cassava harvest to ensure healthy cutting	0.790	0.047	0.050	1373
		(0.035)	(0.035)	
Knows jute sack or other ventilated bag should be used to store cocoa after harvesting	0.899	0.021	0.021	1373
		(0.023)	(0.023)	
Knows that Capsids' control for cocoa should start between August and September	0.401	0.004	0.003	1373
		(0.040)	(0.040)	
Knows that cocoa harvesting should happen one to three weeks after pods are ripe	0.588	0.041	0.042	1373
		(0.045)	(0.045)	
Knows burning groundnut fields after harvest decreases crop yield	0.921	0.011	0.010	1570
		(0.015)	(0.016)	
Knows that groundnut can be stored for more than a year	0.894	-0.024	-0.024	1570
		(0.022)	(0.021)	
Knows groundnut pods are mature when the vines turn yellow and leaves begin to shed	0.941	-0.004	-0.005	1570
		(0.014)	(0.014)	
Knows to enable millet plants to stand firm, one can raise a heap of sand around the base	0.933	-0.012	-0.013	1570
		(0.019)	(0.019)	
Knows that millet should be planted at a depth of 3–4 cm	0.385	0.000	0.000	1570
		(0.032)	(0.032)	
Knows that millet should not be grown on water-logged soil	0.822	0.043	0.040	1570
		(0.027)	(0.027)	

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered at the EA level. Impact estimates report the coefficient on the treatment indicator from an OLS regression of the outcome of interest on the treatment variable, controlling for region and value of the respective outcome at baseline. Extended controls are covariates from baseline – household size, whether household head is female, age of individual responding, whether individual responding is literate, PPI score, and whether individual owns a mobile phone – and order of survey modules. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

D.3 Impact on mobile phone use

Table 10.7: Impact estimates of VFC on female's mobile phone use, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Owns a mobile phone	0.597	-0.040*	1,785	0.394	0.023	1,787	0.069*
		(0.021)			(0.028)		
Has access to a mobile phone	0.883	-0.041**	1,785	0.768	-0.012	1,787	0.402
		(0.019)			(0.028)		
Number of mobile phone numbers primary female owns or has access to	1.145	-0.057	1,785	0.850	0.027	1,787	0.409
		(0.093)			(0.040)		
Fraction of mobile phone numbers that use Vodafone as network provider	0.073	0.042**	1,544	0.339	0.161***	1,361	0.023**
		(0.017)			(0.049)		
Main phone number uses a Vodafone SIM card	0.068	0.035**	1,544	0.341	0.154***	1,361	0.015**
		(0.017)			(0.046)		
Has had main phone number SIM card for over a year	0.748	0.028	1,544	0.788	-0.003	1,361	0.371
		(0.024)			(0.026)		
Likely or very likely to recommend main mobile phone provider	0.882	-0.022	1,544	0.777	0.022	1,361	0.259
		(0.023)			(0.031)		
Used main mobile phone every day in the last 14 days	0.628	-0.010	1,544	0.444	-0.039	1,361	0.487
		(0.027)			(0.033)		
Used main mobile phone in the last 14 days to make calls	0.863	0.009	1,544	0.744	-0.027	1,361	0.347
		(0.017)			(0.035)		
Used main mobile phone in the last 14 days to receive calls	0.885	0.011	1,544	0.789	-0.000	1,361	0.741
		(0.017)			(0.028)		
Used main mobile phone in the last 14 days to send text messages	0.018	0.013	1,544	0.057	-0.012	1,361	0.121
		(0.008)			(0.014)		
Used main mobile phone in the last 14 days to receive text messages	0.358	0.025	1,544	0.227	-0.001	1,361	0.573
		(0.036)			(0.029)		

Used main mobile phone in the last 14 days to send mobile money	0.085	-0.016	1,544	0.061	-0.027*	1,361	0.592
		(0.015)			(0.015)		
Used main mobile phone in the last 14 days to receive mobile money	0.216	-0.025	1,544	0.113	-0.026	1,361	0.984
		(0.022)			(0.021)		
Used main mobile phone in the last 14 days to use mobile internet	0.011	-0.003	1,544	0.013	-0.001	1,361	0.843
		(0.004)			(0.007)		
Has ever used mobile phone to receive agricultural advice	0.010	0.068***	1,521	0.028	0.039***	1,323	0.109
		(0.013)			(0.012)		
Has ever received agriculture and nutrition information via text message	0.009	0.142***	1,506	0.035	0.143***	1,293	0.987
		(0.017)			(0.021)		
Amount spent on airtime on all phones in an average month (GHS)	15.752	-0.158	1,544	6.367	-0.602	1,361	0.700
		(1.035)			(0.514)		
Charges phone at home	0.808	0.009	1,417	0.733	0.040	1,098	0.672
		(0.037)			(0.062)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. Controls include the region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 10.8: Impact estimates of VFC on female's mobile phone use, by mNutrition sub-randomisation arms (dual-headed households only)

	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH=M-HH	N
Owns a mobile phone	-0.003	-0.017	0.535	3,068
	(0.019)	(0.020)		
Has access to a mobile phone	-0.023	-0.027	0.850	3,068
	(0.016)	(0.017)		
Number of mobile phone numbers primary female owns or has access to	-0.039	0.026	0.152	3,068
	(0.039)	(0.040)		
Fraction of mobile phone numbers that use Vodafone as network provider	0.101***	0.098***	0.888	2,514

	(0.017)	(0.018)		
Main phone number uses a Vodafone SIM card	0.092***	0.094***	0.923	2,514
	(0.017)	(0.018)		
Has had main phone number SIM card for over a year	0.012	0.016	0.891	2,514
	(0.020)	(0.021)		
Likely or very likely to recommend main mobile phone provider	-0.022	0.011	0.118	2,514
	(0.018)	(0.018)		
Used main mobile phone every day in the last 14 days	-0.023	-0.026	0.901	2,514
	(0.023)	(0.024)		
Used main mobile phone in the last 14 days to make calls	-0.009	-0.005	0.843	2,514
	(0.019)	(0.020)		
Used main mobile phone in the last 14 days to receive calls	0.012	-0.006	0.403	2,514
	(0.018)	(0.018)		
Used main mobile phone in the last 14 days to send text messages	0.008	-0.012	0.054*	2,514
	(0.009)	(0.009)		
Used main mobile phone in the last 14 days to receive text messages	0.002	-0.014	0.528	2,514
	(0.021)	(0.022)		
Used main mobile phone in the last 14 days to send mobile money	-0.016	-0.021*	0.681	2,514
	(0.011)	(0.011)		
Used main mobile phone in the last 14 days to receive mobile money	-0.015	-0.026	0.559	2,514
	(0.016)	(0.016)		
Used main mobile phone in the last 14 days to use mobile internet	-0.006	-0.006	0.943	2,514
	(0.004)	(0.005)		
Has ever used mobile phone to receive agricultural advice	0.060***	0.032***	0.013**	2,458
	(0.010)	(0.010)		
Has ever received agriculture and nutrition information via text message	0.169***	0.096***	0.000***	2,413
	(0.013)	(0.014)		
Amount spent on airtime on all phones in an average month (GHS)	-0.562	-1.169*	0.403	2,514
	(0.612)	(0.637)		
Charges phone at home	0.011	0.028	0.560	2,146

	(0.025)	(0.026)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses. Reported are the impact estimates of sub-randomisation of eligible households into households where only female receives VFC content and households where only male receive content, and control households. Controls include the region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 10.9: Impact estimates of VFC on male's mobile phone use, by geographic strata

	Mean of comparison, Central	Impact estimates, Central	N	Mean of comparison, Upper West	Impact estimates, Upper West	N	P-value of C=Upper West
Owns a mobile phone	0.872	-0.036*	1,375	0.707	-0.000	1,570	0.222
		(0.019)			(0.022)		
Has access to a mobile phone	0.947	-0.027*	1,375	0.843	0.008	1,570	0.193
		(0.014)			(0.023)		
Number of mobile phone numbers primary female owns or has access to	1.386	0.007	1,375	1.017	0.061	1,570	0.679
		(0.118)			(0.056)		
Fraction of mobile phone numbers that use Vodafone as network provider	0.081	0.096***	1,282	0.366	0.131***	1,344	0.468
		(0.020)			(0.044)		
Main phone number uses a Vodafone SIM card	0.073	0.071***	1,282	0.363	0.115***	1,344	0.293
		(0.019)			(0.037)		
Has had main phone number SIM card for over a year	0.897	-0.030	1,282	0.885	0.003	1,344	0.210
		(0.019)			(0.019)		
Likely or very likely to recommend main mobile phone provider	0.936	-0.035*	1,282	0.887	-0.029	1,344	0.843
		(0.018)			(0.025)		
Used main mobile phone every day in the last 14 days	0.888	-0.026	1,282	0.693	-0.012	1,344	0.733
		(0.020)			(0.034)		
Used main mobile phone in the last 14 days to make calls	0.962	-0.016	1,282	0.910	0.006	1,344	0.338
		(0.012)			(0.020)		
Used main mobile phone in the last 14 days to receive calls	0.957	0.001	1,282	0.925	-0.010	1,344	0.598
		(0.012)			(0.017)		

Used main mobile phone in the last 14 days to send text messages	0.100	0.042**	1,282	0.179	-0.025	1,344	0.022**
		(0.018)			(0.024)		
Used main mobile phone in the last 14 days to receive text messages	0.637	0.008	1,282	0.484	0.015	1,344	0.862
		(0.032)			(0.029)		
Used main mobile phone in the last 14 days to send mobile money	0.242	-0.049**	1,282	0.172	-0.025	1,344	0.520
		(0.023)			(0.029)		
Used main mobile phone in the last 14 days to receive mobile money	0.351	-0.021	1,282	0.269	-0.038	1,344	0.672
		(0.028)			(0.031)		
Used main mobile phone in the last 14 days to use mobile internet	0.036	0.046***	1,282	0.065	-0.023*	1,344	0.000***
		(0.015)			(0.012)		
Has ever used mobile phone to receive agricultural advice	0.043	0.195***	1,270	0.073	0.126***	1,303	0.060*
		(0.029)			(0.023)		
Has ever received agriculture and nutrition information via text message	0.050	0.413***	1,245	0.097	0.355***	1,222	0.133
		(0.026)			(0.029)		
Amount spent on airtime on all phones in an average month (GHS)	37.397	-2.390	1,282	16.092	-0.577	1,344	0.413
		(1.951)			(1.059)		
Charges phone at home	0.802	0.023	1,261	0.738	0.025	1,279	0.976
		(0.034)			(0.046)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses and clustered on the EA level. Reported are programme impacts that are estimated separately for the two regions, Central and Upper West, and the last column reports the p-value from the test of no difference between the two estimated treatment effects. Controls include the region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Table 10.10: Impact estimates of VFC on male's mobile phone use, by mNutrition sub-randomisation arms (dual-headed households only)

	Female-targeted household (F-HH)	Male-targeted household (M-HH)	P-value of F-HH=M-HH	N
Owns a mobile phone	-0.010	-0.021	0.530	2,942
	(0.015)	(0.015)		
Has access to a mobile phone	-0.005	-0.008	0.826	2,942
	(0.013)	(0.013)		
Number of mobile phone numbers primary female owns or has access to	-0.008	0.080*	0.093*	2,942
	(0.046)	(0.045)		
Fraction of mobile phone numbers that use Vodafone as network provider	0.110***	0.118***	0.675	2,625
	(0.016)	(0.016)		
Main phone number uses a Vodafone SIM card	0.082***	0.106***	0.206	2,625
	(0.017)	(0.016)		
Has had main phone number SIM card for over a year	-0.014	-0.014	0.982	2,625
	(0.015)	(0.015)		
Likely or very likely to recommend main mobile phone provider	-0.038***	-0.022	0.324	2,625
	(0.015)	(0.014)		
Used main mobile phone every day in the last 14 days	-0.023	-0.015	0.705	2,625
	(0.019)	(0.019)		
Used main mobile phone in the last 14 days to make calls	-0.007	-0.002	0.676	2,625
	(0.012)	(0.011)		
Used main mobile phone in the last 14 days to receive calls	-0.011	0.001	0.384	2,625
	(0.011)	(0.011)		
Used main mobile phone in the last 14 days to send text messages	0.019	-0.005	0.209	2,625
	(0.016)	(0.016)		
Used main mobile phone in the last 14 days to receive text messages	0.002	0.019	0.531	2,625
	(0.023)	(0.023)		
Used main mobile phone in the last 14 days to send mobile money	-0.046**	-0.028	0.403	2,625

	(0.018)	(0.018)		
Used main mobile phone in the last 14 days to receive mobile money	-0.039*	-0.021	0.443	2,625
	(0.021)	(0.021)		
Used main mobile phone in the last 14 days to use mobile internet	0.022**	-0.001	0.049**	2,625
	(0.010)	(0.010)		
Has ever used mobile phone to receive agricultural advice	0.121***	0.196***	0.000***	2,572
	(0.016)	(0.016)		
Has ever received agriculture and nutrition information via text message	0.308***	0.457***	0.000***	2,466
	(0.020)	(0.019)		
Amount spent on airtime on all phones in an average month (GHS)	-1.506	-1.522	0.991	2,625
	(1.287)	(1.265)		
Charges phone at home	0.044**	0.006	0.079*	2,539
	(0.019)	(0.018)		

Note: Estimates from the mNutrition Ghana endline survey sample. Standard errors are in parentheses. Reported are the impact estimates of sub-randomisation of eligible households into households where only female receives VFC content and households where only male receive content, and control households. Controls include the region and value of the respective outcome at baseline. *p<0.10 **p<0.05 ***p<0.01

Source: Authors' own

Annex E Household survey instrument

Endline Household Questionnaire